VOLUME LXI NUMBER 9 WHOLE 542

SCHOOL SCIENCE AND MATHEMATICS

DECEMBER 1961

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Second-class postage paid at Menasha, Wisconsin and at additional mailing offices. Published Monthly except July, August and September at Curtis Reed Plaza, Menasha, Wis. PRICE: Six dollars a year; foreign countries $6.50; current single copies 75 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

Printed in the United States of America

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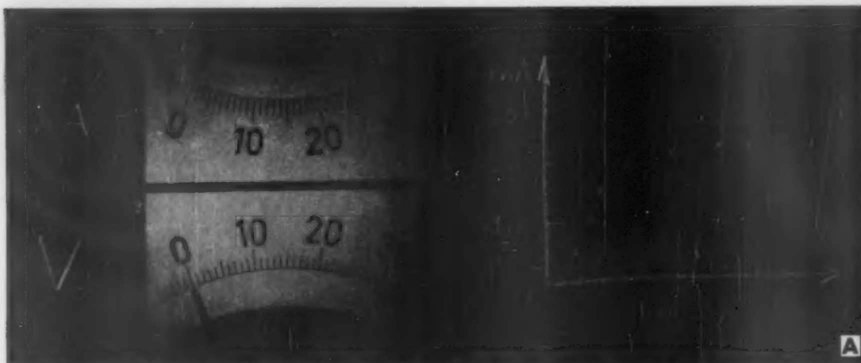
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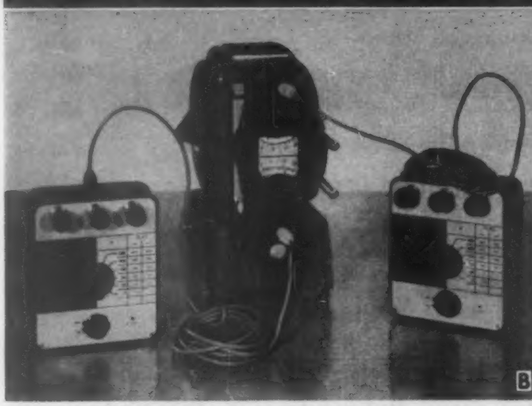
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SCHOOL SCIENCE AND MATHEMATICS

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Our Land—Today and Tomorrow

D. A. Williams[1]

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The very abundance of land—good land—and its bounty of good water, grass, forest, and wildlife have enabled Americans to be profligate in their use to the point of waste, depletion, and destruction. There remains a deep sense of complacency. Too many people take it for granted that there will always be surplus food and fiber, adequate water and wood products, enough wildlife, recreation areas, and what the Germans call "Lebensraum," or room for living.

Others gloomily point out that our rapidly expanding population will soon eat up all the surplus, appropriate all of the water, and occupy all of the living space.

Neither group is wholly right. Certainly this is no time for complacency, but neither is it a time for pessimism.

America's overall land balance has kept handily ahead of the drafts against it. With about six per cent of the world's land area including 18 per cent of its arable land, and with seven per cent of its population, we are in an enviable position. We still have 3¾ acres of cultivable land per person, and we have not approached the foreseeable limits of our capacity to increase production through scientific technological improvements.

"We in America enjoy a situation that is rare in human history. We have enough to eat," said President John F. Kennedy when, as president-elect, he pledged his efforts in behalf of an expanded soil

[1] Adapted from a paper presented by Mr. Williams at the American Association for the Advancement of Science, New York City, December 27, 1960.

and water conservation program. But he also pointed out: "There is too little public recognition of how much we all depend upon farmers as stewards of our soil, water, and wildlife resources."

How we handle our land is the key to meeting our future needs.

The U. S. Department of Agriculture recently completed its national inventory of soil and water conservation needs, covering about $1\frac{1}{2}$ billion acres available for agriculture on the mainland and in Alaska, Hawaii, and Puerto Rico. It is the most comprehensive fact-finding job the nation has ever undertaken with respect to its basic productive soil and water resources. Excluded were the greater part of the nearly 395 million acres of Federal land, and approximately 50 million acres in urban and built-up areas.

Thirty thousand people working as county and state committees developed the inventory and assembled all available pertinent economic and physical information to show (1) The kinds of land we have and the acreages in each capability class, (2) how the land was being used as of 1958–59, including urban and built-up areas, (3) comparable land uses expected by 1975, based on present trends, (4) the acreage of surface water, from farm ponds to major reservoirs, and (5) important conservation problems, including watershed project needs.

Of the inventoried acreage, approximately 444 million acres is used as cropland, 486 million acres as pasture or range, 449 million acres as forest or woodland, and 69 million acres in such other land uses as farmsteads, rural residences, and unused odd areas. Forty million acres are covered by water, with about eight million acres in smaller water areas (reservoirs less than 40 acres in size and streams less than one-eighth mile wide), 13 million acres in large reservoirs, and 19 million acres in other larger water areas.

Widespread changes are taking place in the use we make of our land. Urban and built-up areas are growing at the rate of $1\frac{1}{3}$ million acres each year, and most of it is on our better agricultural land. One strip extending through nine Seaboard states from Massachusetts to Virginia will grow by 2,800,000 acres by 1975. Six states, California, Florida, Illinois, Michigan, Ohio, and Texas will each lose a million acres to urbanization by that date.

Other things are happening to our agricultural land. More of it is going under water as large and small lakes are built. Shifts from one type of enterprise to another are widespread.

In the Southeast, for example, cattle numbers and grassland acreages have made a phenomenal increase in the last two decades and more land is being planted to trees. This shift from cropland is partly offset by additional acreages brought into cultivation on the Coastal Plains, the Mississippi Delta, and Florida, and Western

lands being brought under irrigation.

These trends have been pin-pointed county by county and state by state in the Conservation Needs Inventory. A detailed summary of the quality of our land was made. Based on land capability summaries and problems in conservation, the following facts have become evident:

About two-fifths of the agricultural land inventoried, or some 626 million acres, is in Land Classes I, II, and III, and therefore suitable for continuous cultivation. About 58% of this already is cultivated. Approximately 235 million acres, or 38%, is in woodland or grass, while more than 27 million acres is in other uses.

Class IV land, suited to limited cultivation, accounts for 167 million acres. Twenty-eight per cent is cultivated and presents a continuing problem in conservation.

Classes V through VIII represents 631 million acres not suited to any type of cultivation. This is about 44% of the agricultural land inventoried. Yet about 25 million acres actually is in cultivation and should be put to safer uses.

Conservation problems are many and varied. Erosion is the dominant problem on half of the cropland, and excess water is a problem on 20%. Only 56 million acres, or about one in 25 acres of agricultural land, is the very best Class I land not requiring specific conservation treatment for its safe cultivation, and nearly three-fourths of this land is now being cultivated.

More than 90 million acres of wetland in Classes II-IV is not being cultivated.

Land and water problems do not come singly, nor can they be treated without consideration of other needs of the area. It is recognized that the natural area for study and treatment of problems is not the farm, or a geographical community, but rather on the basis of watersheds conforming to natural drainage patterns. Under the USDA small watershed programs, each needed land treatment is considered in relation to the others and to the water produced on the watershed. Corrective measures are planned for each acre needing treatment. Maximum use of water for many purposes may become a part of the plan.

It is significant, then, that 12,000 watersheds of suitable size for projects under the Watershed Protection and Flood Prevention Act or similar programs were delineated. Project action is needed on about 8,000 watersheds covering nearly a billion acres—about half of the total area of the mainland United States!

All of this, and much other information developed by the National Conservation Needs Inventory, outlines the trends in agriculture and the needs for protecting soil and water resources.

This is the basis on which plans will be made to feed and clothe the 230 million people which the Bureau of the Census estimates will depend on these resources by 1975—a scant 14 years from now—and perhaps a population of 370 million by the year 2010. Our land must produce proportionately more meat, dairy and poultry products, food grains, fruit, vegetables, and other food for this soaring population. It must supply more fiber, more wood products, and more materials for industry. It must supply space for growing urbanization, for industry, and for roads.

Still some space must be saved for recreation—on land and water. More than two million acres of water need development for recreational uses. Much more good water will be needed for personal use, for sanitation, for industry, for agriculture. The quality of surface water is dependent to a large extent on the condition of the watersheds on which rain falls. While this discussion pertains more to land use and land treatment, the close relation of water and land can not be ignored.

What then of our future needs?

We will need 200 million more acres of cropland to meet 1975 needs on the basis of 1956 yields. While we have that much additional land physically suitable for cultivation, the pressures of other needs will keep us from using it for crop production. Actually, about 10.5 million acres presently cultivated will be put to other uses. Therefore, we will have to depend on increased yields brought about by crop and livestock improvements, pest controls, fertilizer and tillage advancements, on land improvement through irrigation, drainage, or clearing, and on soil and water conservation. It is estimated that there will be a net decrease of two per cent in cultivated acreage by 1975.

At the same time, the acreage of pasture and range will increase about 2%. The 365 million acres of inventoried pasture and range land needs treatment of some kind to increase production and to protect it from erosion and depletion.

There will be about two per cent less forest and woodland acreage to provide timber and wood products. The reduction will be principally in the non-commercial woodlands of the southern Great Plains states. The inventory shows that more than 150 million acres of forest and woodland need timber stand improvement. Trees need to be planted on 70 million acres.

The Conservation Needs Inventory will help to show the way to maintain our favorable position with respect to our land and water resources. It can be an important basis for zoning, land-use allocations and other facets of planning for the future by town and county governing bodies. It will help them to find room for developments without unnecessarily sacrificing our best land.

As for agricultural land, the principal job for maintenance and improvement belongs to the landowners. Guiding and helping them will be the nation's nearly 3,000 Soil Conservation Districts which cover 90% of the country's farmland and 95% of its farms. These districts help to bring assistance from federal, state, and local sources to bear on the problems. In each district locally-selected supervisors direct the activities of the district and help to coordinate soil and water conservation programs on farms. Between 22 and 23 million acres are being conservation planned each year through the district program.

The United States Department of Agriculture provides technical help, cost-sharing, loans, education and other aid. Conservation has been facilitated, also, on substantial acreages outside the district program through the Agricultural Conservation Program, Conservation Reserve, and other programs.

No one can urge a restriction in the growth of municipalities, other built-up areas, or roads which are expanding on the nation's good land. But the fact that there is a growing land shortage which can be foreseen, and which can be measured, will provide incentive for local planning authorities to guide developments away, as much as possible, from the better land needed for the production of vegetables, milk, and other farm products.

With the facts provided by the National Conservation Needs Inventory, and with detailed soil surveys and other information which can be provided by the Soil Conservation Service, we hope to see greater community support and action in areas of complex municipal, industrial, agricultural, and recreational interrelationships. Responsible local governments and their planning bodies, backed by an informed public, can be an important factor in planning for a secure future for the nation.

GULF STREAM EXTENSION SEEN IN PLANKTON FIND

The finding of warm-water species of plankton in the North Atlantic Ocean, northeast of the Newfoundland Grand Banks, has led to speculation that a "temporary extension" of the Gulf Stream current system may have brought them there.

V. Bainbridge of the Oceanographic Laboratory, Edinburgh, reported in the British scientific journal *Nature* that patches of warm-water zooplankton, minute oceanic animal life, were present in samplings taken in February, 1960, and March, 1961, at times when the area's surface temperatures were near their lowest.

The region is the meeting place of the cold water of the Labrador current from the north and the warmer waters of the North Atlantic current from the south. The theory is that the warm Gulf Stream current, flowing from the Gulf of Mexico along the U. S. coast to Nantucket Island, Massachusetts, and from there eastward, may be entering the area northeast of the Grand Banks at intervals not yet determined. Further plankton samplings and study are needed, Mr. Bainbridge said.

The World's Largest Globe*

Arthur A. Delaney

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New Hyde Park, New York

Most natural gas storage tanks are large, cylindrical affairs, totally devoid of any aesthetic charm. Such tanks, although necessary to the economic well-being of a community, do little to enhance the beauty of the neighborhood in which it is constructed. Few communities have been able successfully to transform the drab, utilitarian appearance of a storage tank into anything but the stereotype of a cheerless-looking container. Utility companies and town boards usually solve this problem by locating such storage tanks in the industrial sections of a town or city.

Approximately four years ago, the Savannah Gas Company found it necessary to expand its gas transmission lines to keep pace with the rapid industrial and residential growth of Georgia's largest port city. A new storage facility was needed to augment the added transmission lines. Unlike most situations, circumstances required the proposed site for the holder to be near a highgrade residential area. After several negotiations, permission was finally obtained from the Board of County Commissioners to locate the storage tank in this area.

The company, mindful of the unpleasant view created by typical cylindrical tanks, entered into contract with the Chicago Bridge and Iron Company to build an all-steel spherical tank, now technically known as a Hortonsphere. The tank is sixty feet in diameter, higher than a five-story building, and located on top a skirt-type support with a vertical height of six feet, six inches. The holder has a storage capacity of 600,000 cubic feet of natural gas at seventy-five pounds pressure. Costing approximately $190,000 it is the first storage tank ever constructed in this manner.

After the initial phase of construction was completed, the globe attracted considerable attention. Painted an attractive sea-green color, the Hortonsphere did not exhibit the usual blemish associated with storage tanks. When construction was finally completed, Mr. H. H. Hillyer, Company President, proposed that the globe serve a purpose in addition to that of gas storage. Since the structure was globular in shape, why not paint a map of the world on it? Residents of the community objected to the plan, obviously proposed as an educative measure and one that would enhance the beauty of the community! The proposal did attract the favorable opinion of many citizens, however, and inquires as to when the company would pro-

* The author wishes to acknowledge Mr. Waldo Spence, Director of the New Homes Division, Savannah Gas Company, for much of the information contained in this article.

ceed with plans to pain a map on the holder flooded the main office. Finally, after approximately three months of community deliberation, the civic organizations of Savannah notified the Board of County Commissioners that they had no objections to the painting of a world map on the holder.

The plan was to paint a planimetric political map on the holder, delimited to a definite and proportional scale. Most commercially-fabricated table globes are made to rotate on an axis that is fixed

Savannah Gas Company Photo

This all-steel global holder for natural gas, especially designed for the Savannah Gas Company, measures 60-feet in diameter and is the world's largest globe, colored and constructed to scale, in the world today. It contains a reserve supply of natural gas for Georgia's largest port city.

in an inclined position. We are so accustomed to seeing the earth's axis tilted $66\frac{1}{2}°$ with the plane of the ecliptic and on an inclination of $23\frac{1}{2}°$ from a line perpendicular to the ecliptic, that it was necessary to present this concept when painting the holder. Thus, as seen in figure 1, the North Pole is tilted $23\frac{1}{2}°$ from the gas valves which mark the geometric top of the holder.

Mr. Leo Berkemeier, noted artist, was contracted to lay out the outline and paint the map. He attacked his gigantic problem with all the skill and painstaking perserverence common to the most careful cartographer. Unfortunately, Mr. Berkemeier fell from approximately forty-feet while in the final hour of painting. The artist's fall resulted in a broken back and compound fractures of both ankles. The work was completed, however, and today the "World's Largest World" is one of Savannah's most famous landmarks.

MORE HEAT IN ANTARCTICA FROM WIND THAN VAPOR

The amount of heat flowing into the Antarctic each year by wind is seven to ten times greater than the amount carried in by water vapor.

The heat transport per year amounts to 2,000 times the electrical energy produced in the U. S. in 1957. These calculations are based on meteorological and glaciological data gathered during and after the International Geophysical Year.

Since water vapor and wind are the only means by which any appreciable amounts of heat are carried into the Antarctic, the sum of the latent heat and the measurable heat gives a good estimate of the heat lost by radiation through the top of the atmosphere. The calculation of radiation loss is 15% lower than previous estimates. This energy loss will be measured directly by the Nimbus weather satellite to be launched sometime in 1962.

NEW DISCOVERIES SHED LIGHT ON HOW PLANTS FORM FOOD

Photosynthesis, the process by which green plants manufacture food, depends on two primary photochemical reactions rather than one as has been previously believed.

The two photochemical reactions involve the conversion of light energy to chemical energy by the formation of certain energy-rich chemical compounds. The process must proceed at balanced rates if efficient photosynthesis is to result.

What is affected is chlorophyll-a. His studies show that this main blue-green pigment, known to take up light energy directly from other pigments in green plants, has at least two components with slightly displcaed absorption bands.

Activation of only one of these components by light is not enough to produce photosynthesis. But if both are excited at the same time, complete photosynthesis results.

It was also found that plant cells contain small amounts of a new pigment capable of inhibiting the photosynthetic activity of "inefficient" forms of chlorophyll-a. "Inefficient" forms produce oxygen in the presence of light but do not reduce carbon dioxide necessary for full photosynthesis. The inhibiting pigment, however, does not affect the chlorophyll-a that received absorbed light by transfer from other pigments.

The scientist believes ultimately it will be possible to concentrate and isolate this new pigment.

Business-Sponsored Films for Physical Science

Bertha Elizabeth Slye
Kalamazoo, Michigan

Introduction

For many years business-sponsored films have been widely used in instruction in the science classroom. In the last decade in particular, the development of atomic and space technology as well as the growing interest in science, have made it necessary for the teachers to go beyond the confines of information in the ordinary science textbook and use visual aids from business-sponsors.

The use of these films has created many problems for the administrators. They must decide whether the materials are educationally sound or whether they are merely vehicles of propaganda. Thus much has been written recently by school administrators and business leaders in an attempt to encourage the improvement of the films for educational use. In some cases, concrete action has been taken by groups of educational and business personnel to establish some type of criteria for the development of business-sponsored films for school use. Without doubt, however, there is still a great need for more and better visual materials of this kind.

Teachers have stimulated the development and circulation of science films through their requests for them from sponsors and distributing agencies. Recent reports of business-sponsors indicated an increase in the number of films available for teachers, with circulation per print running into the hundreds of thousands. Yet in a preliminary poll conducted by the author, of ninety-eight sponsors who claimed to have released a total of four hundred thirteen (413) 16 mm. films during the period of 1950 to 1958, it was found that two hundred thirteen (213) of those films were not identified as being business-sponsored in any of the source lists under study. Since the source lists covered the period from 1953 to the publication date of 1956, and the films released covered the period from 1950 to 1958, it is assumed those films released after 1956 were not likely to appear on the lists. There were seventy-four (74) films released after 1956. Thus one hundred thirty-nine (139) films that might reasonably have been found on the source lists under study, published from 1950–1958 were not identified as being business-sponsored.

The Problem and Its Background

The purpose of the study, therefore, was to determine the extent to which business-sponsored films for physical science appeared on approved source lists; and further, to determine how they were identified

on such lists as being business-sponsored. The term "business-sponsored film" refers to a film sponsored by a firm based on products manufactured by it, or the research involved by its production. The term "identification" as used in this study means the listing of a business-sponsored film in a source list, together with the proper credit line to the business-sponsor. "Source lists" are those lists of approved films available to teachers for loan, rental, or purchase for use in the selection of classroom films. The lists under study included those published since 1950 by universities, state departments of education, city school systems, and by authors of selected science texts in current use. Since a large number of the business-sponsored films are related to the physical sciences, it seemed advisable to the author to delimit the study to this area. The term "physical science" is deemed to include the subjects of physics, chemistry, earth sciences and the related fields.

The study concerned itself with the following activities: (1) an analysis of the related literature in the field dealing with (a) changing attitudes towards the use of the business-sponsored materials in the classroom; and (b) organized efforts of business and educational groups to establish acceptable criteria for listing various audio-visual aids of the business-sponsored variety in source lists. (2) a survey of high-school texts published since 1950 to identify the topics of physical science included in them. (3) an analysis of a number of publications of universities, state departments of education, city school systems and the teacher's guidebooks of recognized science texts published since 1950, in order to identify business-sponsored films available for use by teachers of physical science; (4) the results of a poll of one hundred thirty-seven (137) business sponsors to identify the films that were released since 1950 and which were available for classroom use.

The report concluded with a summary of observations made during the tabulation of the various data, some recommendations concerning followup activities, of studies and conferences to improve the number of listings of film material in source lists.

Review of the Related Literature

The use of any business-sponsored supplementary teaching aids, including the 16 mm. films has been affected by: (1) the changing attitudes of educational leaders to their effective use within the classroom; and, the response of business organizations to the use of the materials as educational media. (2) the efforts of educational and business leaders to set up standards of acceptability of the aids for classroom use.

There have been published many discursive writings and reports of research concerning the use of business-sponsored aids. An analysis of ten of these reports of research supplied evidence about trends in the thinking of business and education leaders through the developmental period. In the early stages there was general apathy on the part of school administrators towards the acceptance of any business-sponsored materials, and stiff regulations imposed by state and local boards of education on the use of such materials. Later, as the quality of the business aids improved, restrictions on their use were lessened, and there evolved a change of attitude on the part of educational leaders. The emphasis hinged on the importance of the aids in making contributions to the learning processes; and with advertising kept to the minimum credit line. Finally, there has been a willingness on the part of educators to find a common ground of understanding with industry that will lead to the production of superior business-sponsored materials.

A further study of the numerous writings indicated a favorable trend in the field of evaluation and general improvement of the audio-visual aids. Many national business and educational groups have established criteria in the production and selection of them. Particularly, the improvement has been most marked in the production of the 16 mm. films.

The National Education Association was one of the first groups to establish a milestone in the techniques of evaluation. In 1939 they appointed a committee to study propaganda in the schools. The purpose was to (1) define the general scope of the problem; (2) point out the significance, and (3) outline broadly the principles which school systems might find helpful in their efforts to sort from a wide variety of outside materials and influences, those useful for the school program.

In 1946, the superintendent of schools in Denver, Colorado appointed a committee to consider the extent to which materials containing advertising could be used for instructional purposes.

In 1946, The Consumer Education Study of the National Education Association of the Secondary School Principals, a department of the National Education Association undertook a constructive program in the field of audio-visual education. The program was designed to help discover, develop, and promote the best methods for producing and using audio-visual materials. They collaborated with the National Science Teachers Association in the preparation of a report designed to provide sponsors with suggestions for the development of teaching aids for use in science teaching. They cooperated with a committee appointed by the American Vocational Association in the

preparation of desirable lists of teaching aids and standards for the preparation and selection of such aids.

At the Michigan Audio-Visual Conference held in Detroit in 1948, a committee of leading figures in the field of audio-visual education prepared a report on "A Suggested Policy with Regard to Sponsored Materials Offered for School Use."

1948, a significant milestone in the field of the improvement of audio-visual aids was reached, when representatives of business and science education united to form the Advisory Council on Industry-Science Teaching Relations. As an activity of the National Science Teachers Association it was launched to promote good science teaching by the improvement of industry's offerings and by teaching teachers to make the best use of this offering in the classrooms of the nation. The Pittsburgh regional conference in 1949 was one of the techniques used by the Council to bring its objectives and services to both industry and science teachers throughout the nation. One of the major projects of the Advisory Council was to launch a five-fold program, known as CEDUR: (1) a consultation service providing help for industry in the planning and producing of business-sponsored aids to science teaching; (2) an evaluation service to determine the usefulness of the materials; (3) a distribution service for purpose of mailing acceptable materials to the members of the National Science Teachers Association; (4) a utilization service of finding desirable ways of utilizing the aids within the classroom; and (5), the designing of research studies to uncover the best teaching uses of business-sponsored materials and the curriculum areas best served by them.

During 1949–1950, the education department of Hill and Knowlton, Inc. undertook an extensive research study to discover guiding principles of a sound course of action in education-industry cooperation. The recommendations and observations emerging from the study were based on the need for an effective program of making available opportunities for greater cooperation with the schools; establishment of standards to meet the needs of the educators in the selection of sponsoring materials; exploration of undeveloped areas of industrial programs useful for education; and methods for assuring the improvement of relations between industry and the schools. Among the educational requirements listed were: (1) a careful study of instructional needs by those designing sponsored materials and programs; (2) designing of materials and services by industry and education working together to fit the changing school; (3) familiarity with use of materials prior to distribution; (4) preparation of materials appropriate to the age, grade and interest level of the potential users; (5) placement of materials in the hands of those who want them because they have a real need for them; (6) analysis of materials by specialists to

assure their suitability; (7) acceptance of opportunities for cooperating on the development of standards for evaluating materials and services; and, (8) measurement of educational material by the strictest standards that educational leaders have established.

In 1955, the Clearing House of the Department of Mass Communication of UNESCO, under the auspices of the Educational Film Library Association, issued a manual for evaluators of films and filmstrips.

In 1955, the Association of National Advertisers appointed a Film Steering Committee which prepared and presented twenty-two check points

> "Covering curriculum needs, subject matter, and production and distribution requirements—as a guide to businessmen in the production of films and other audio-visual materials intended for classroom and related audiences, and as a guide in their selection."

In 1956, The Fund for the Advancement of Education made a grant of $11,500 to the Phillips Academy at Andover, Massachusetts for the development of an interesting course in chemistry on film. The project under the direction of Elbert C. Weaver, instructor of chemistry at Phillips Academy had two parts: (1) A survey of existing films and filmstrips as to their suitability in whole or in part for inclusion in the essentials of a minimal integrated course in elementary chemistry on film, and to decide what supplements are necessary to make a coherent course. (2) The production of a series of films and filmstrips that together with the material previously selected, shall constitute the essentials of a course in chemistry on films.

The efforts of the various educational and business groups to establish criteria for the selection or production of aids for the classroom have been continuous. However, the appearance of such films on approved lists lag far behind the improvement of the films.

Methods Employed

An analysis was made of thirteen representative high-school science textbooks published since 1950 and in use throughout the country, in order to determine the areas of science presented to the students. It was assumed that the areas covered would serve as criteria for the selection of any 16 mm. films available for use in this classroom. The varieties of textbooks were analyzed to identify the areas ordinarily covered by the physical sciences. They included the following:

1. Textbooks of chemistry and physics organized around the traditional units.
2. Textbooks of general science in which a unified presentation of the various sciences was emphasized. The biological units were omitted for consideration in the study.

Representative educational institutions of each state publishing

catalogs of the 16 mm. films available in their libraries for teaching science at the secondary level, were invited to submit their current issues for review. The catalogs that were received and studied included those of thirty-seven (37) universities and state colleges: six (6) state departments of education: and eight (8) city school systems. In addition the lists of films found in the teacher's guidebooks for nine (9) science texts published since 1950 were included in the analysis. The list of 16 mm. films for physical science found in each catalog of audio-visual materials were tabulated according to the following pattern: (1) name of educational institution: (2) catalog year; (3) total number of films for physical science; (4) total number of business-sponsored films; and, (5) ratio of business-sponsored films to total number of films listed for physical science. Table I following presents the median figures taken from the analyses of each category of lists in the study.

TABLE I

MEDIANS

**LISTINGS: PHYSICAL SCIENCE FILMS

Source List	Number Under Study	Medians Total Number Physical Science 16 Mm. Films	Medians Total Number Business-Sponsored 16 Mm. Films	Mean Ratio
Universities Colleges	37	203	29	12.5
State Department Education	6	182.5	7	5.5+
City School Systems	8	206.5	41	16.2
Science Texts	9	10	9	9.1

** Median figures were taken from the results of the tabulations of each of the categories of film lists under study.

A copy of the results of the survey was submitted to each of one hundred thirty-seven (137) business sponsors for review. In addition a questionnaire was sent requesting information on available business-sponsored 16 mm. films released since 1950 that might be pertinent to the field of teaching of the physical sciences. A partial copy of the questionnaire covering two of the major points follows:

"*Purpose of the survey:* to obtain available information on:

(a) production of 16 mm. films by your firm with or without the aid of a consulting group of science educators or agency, qualified to judge the merits of the films or their acceptability for approved use in the classroom, and

(b) school circulation statistics, if available, on each film, based on a recent yearly computation

"*Scope of the survey:* is limited to:

(a) those films produced since 1950, for a greater effort has been expended to

bring the films up to recognized specifications, and
(b) those films most actively received by teachers for use in the classroom."

A total of ninety-eight (98) sponsors out of the one hundred thirty-seven (137) polled responded to the questionnaire and submitted a list of four hundred thirteen (413) 16 mm. films available since 1950 for listing in the numerous source lists. The films were checked for inclusion in film catalogues and teacher's guidebooks of the science texts according to the following procedure:

a) Category: university, state department of education, city school system, or science text.
b) Publication date of catalogue or text.
c) Registration of the available films in each of the source lists.
d) Total number of available films from 1950 to publication date of each of the source lists under study.
e) Ratio of registered films to total number of available films, from 1950 to publication date of the source list.

The following, Table II, presents the median figures, taken from the "Summary Analyses of the Registration of the Available Films Released Since 1950," in each of the source list categories.

TABLE II

MEDIANS

REGISTRATION: 16 MM. B-S FILMS AVAILABLE SINCE 1950

Source List	Publication Date	Registration B-S Films	Total No. Available B-S Films from 1950 to Publication Date	Ratio
Universities Colleges	1955–56	20	316	6.9
State Department Education	1956	3	316	1.3
City School Systems	1955	18	260	6.9
Science Texts	1952	4	103	1.8

CONCLUSIONS AND RECOMMENDATIONS

Purpose of the Study was to determine (1) the extent to which business-sponsored films for physical science appear on approved source lists that are available to the science teacher; and, (2) how they are being identified as being business-sponsored.

The major findings of this investigation indicated that there were available a large number of films released since 1950 for use by the teachers of the physical sciences. However, the findings show a low ratio of identification of the business-sponsored films on approved

source lists. The results of the study point to the need for further studies on the (1) responses of educational leaders and publishers of source lists to the use of business-sponsored films; (2) quality of the available business-sponsored films in terms of several sets of criteria established by business and education; (3) techniques of familiarizing educators and publishers of source lists with the available films for use in the science classroom; and, (4) the cost factor in the purchase of films for examination, listing and distribution.

The author made several observations in the collection of data from the numerous film lists:

1. There is a lack of a unified system of listing of films, giving credit to any producer, distributor or sponsor, with some films listed in various catalogs appearing with a credit line to a producer or sponsor in one catalog, and to a different producer or sponsor in other catalogs.
2. The release dates of films are frequently omitted thus causing confusion for teachers desiring factual information about current material for the teaching of science.
3. Often films long since withdrawn from circulation by the distributors, producers or sponsors are listed as being available.
4. There are discrepancies in the listing of actual titles of the films.

On the basis of the study the following recommendations were made by the author: that a joint committee of representatives from business sponsors, educators and producers of source lists for teachers, be formed to study the available film material and compilation of source lists to accomplish the following:

1. Undertake a series of follow-up studies to determine the reasons for refusal to include films for approved lists.
2. Establish effective ways for keeping publishers of source lists informed of current material.
3. Determine optimal life-span of 16 mm. films for teaching purposes.
4. Establish a plan of deleting titles when the films are withdrawn from circulation.
5. Increase the effectiveness of the source lists, by setting a plan for the listing of film material with adequate description and proper credit line to the producer or sponsor, and with the release date of the film.
6. Establish a program for the advance showing of films to publishers of source lists who are responsible for the selection of the films listed in the various source catalogs.

A Challenge

We are living in an important age in which science teachers and their students must have access to the best current scientific information if science education is to improve. The information must be channeled from the laboratories including those of business responsible for changing our patterns of living. If the channels permitting the flow of information are blocked with inadequate data and outdated information, the students as well as the teachers will lose out.

The speed with which the achievements of science created in our

laboratories are revolutionizing ourselves and environment, is fantastic. The atomic and space age is here now, and the students are a part of it, coping with its problems and its power. It is the responsibility of business and educational leaders, as well as the leaders in the scientific field to see that information on pure and applied science is adequate and useful for those who must use it, and that the channels permitting the flow of information to recognized lists of materials are kept free from barriers of misinformation or prejudice. The students of today must have informed teachers who know how to make use of this information on scientific processes dealing with problems affecting their structure of society. Only then can they face the challenge of fresh problems created by each new scientific adventure.

ARCTIC EXPEDITION FINDS RECORD OF 1945 FALLOUT

A record of radioactive fallout from the 1945 atomic bursts over Hiroshima and Nagasaki is believed to have been found embedded in an icecap in northern Ellesmere Island, Canada's northernmost territory.

Glaciologist Dr. Geoffrey Hattersley-Smith of the Canadian Defence Research Board says he took ice samples from a 50-foot hole he dug in the icecap, melted them down and sent them to the atomic plant at Chalk River, Ontario, for analysis.

He said the sample of 1945–46 snowfall is expected to show the density of fallout from the atomic blasts over the two Japanese cities.

From the bottom of his 50-foot ice pit, dug with pick and shovel, Dr. Hattersley-Smith obtained an 80-foot bore, giving him a climatological record of more than 100 years. He says there is some indication summers have been slightly warmer in the last 20 years.

The expedition found fossilized plants believed to be several hundred million years old—the oldest ever found in the Arctic—and wood judged tens of millions of years old. The tree wood was found on a rock outcrop at the 4,000-foot level of the Gillman glacier.

The finds confirmed the theory that ages ago Arctic Canada was tropical or sub-tropical. On an earlier expedition, Dr. Hattersley-Smith found coral in the same region.

The expedition also helped the U. S. Air Force find suitable aircraft emergency landing strips. Lake Hazen is 360 miles north of Thule, Greenland.

PRIVATE INDUSTRY WILL COMPLETE MOHOLE PROJECT

Representatives from oil companies and other industries are now bidding on a contract to complete the Government's Project Mohole. The project is an attempt to penetrate through the earth's crust to the underlying mantle.

About ten companies have submitted proposals to handle the engineering and management of the spectacular project, the National Science Foundation said. The Foundation is financing most of the project.

Although the prime purpose of the project is to tell scientists more about the formation of the earth, oil industries will greatly benefit from the new drilling techniques and equipment developed.

The actual Mohole will probably be drilled in about three miles of water where it will penetrate through three miles of ocean-bottom layers to reach the mantle.

In preliminary tests conducted last spring scientists drilled a 600-foot hole in 11,700 feet of water to prove the feasibility of the project.

Periodic Absolute Value Functions

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It has been shown in earlier issues of School Science and Mathematics (December, 1958, and March, 1960) that the absolute value notation provides a rather versatile and simple method for defining many interesting and useful functions. In order to further illustrate the convenience of the absolute value notation, its application in the definition of such functions as "square waves," saw-tooth functions, and periodic step functions is presented in the following discussion.

One square wave function which may be defined with absolute value notation is given by

$$y=\frac{|\sin x|}{\sin x} \tag{1}$$

The graph of this function is shown in Figure 1.

It should be noted that expressions such as the right hand member of (1) are undefined at $\sin x=0$. This merely indicates that the indefinite integral has an abrupt change of slope at $\sin x=0$.

It has been found that the anti-derivative (indefinite integral) of (1) is given by

$$\int \frac{|\sin x|}{\sin x}\,dx=\arcsin(-\cos x) \tag{2}$$

The function, $\arcsin(-\cos x)$, is graphed in Figure 2. Conventional differentiation proves the validity of the anti-derivative, equation (2), as follows:

$$\frac{d[\arcsin(-\cos x)]}{dx}=\frac{\sin x}{\sqrt{1-\cos^2 x}}=\frac{\sin x}{\sqrt{\sin^2 x}}=\frac{\sin x}{|\sin x|}=\frac{|\sin x|}{\sin x}$$

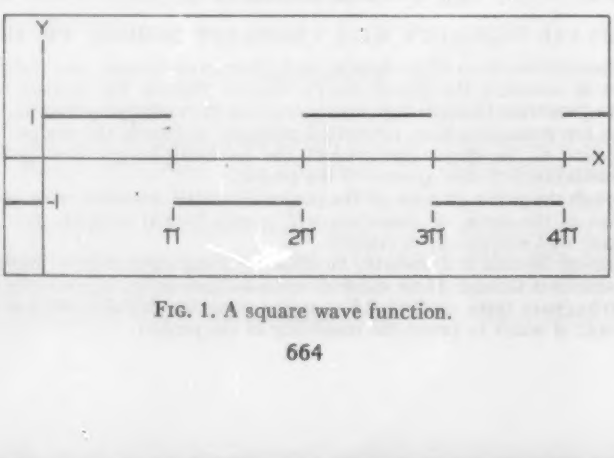

Fig. 1. A square wave function.

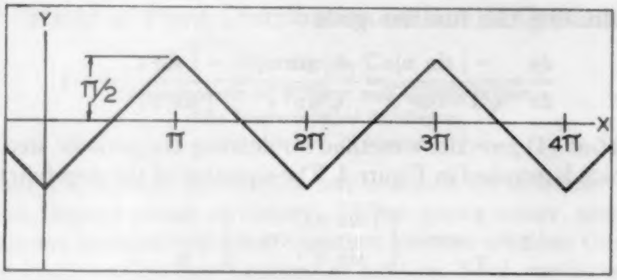

FIG. 2. A saw-tooth function.

The significance of the two foregoing equations should be noted. The function, arcsin $(-\cos x)$, is NOT an absolute value function, but its derivative IS. Since this conclusion follows from conventional differentiation, the absolute value notation must be considered a natural part of our conventional mathematical system.

One great advantage of the absolute value notation stems from the fact that it permits the development of functions the anti-derivatives of which are easily determined by elementary methods. The anti-derivative of the function, arcsin $(-\cos x)$, is given by

$$\int \arcsin(-\cos x)dx = \frac{1}{2}\left[\arcsin(-\cos x)\right]^2 \cdot \frac{|\sin x|}{\sin x} - \frac{\pi^2}{8} \cdot \frac{|\sin x|}{\sin x} \tag{3}$$

Again, differentiation* will prove the validity of equation (3).

The saw-tooth function which is graphed in Figure 3 is defined by

$$y = \arcsin\left[\frac{|\sin x|}{\sin x} \cos x\right] + \frac{\pi}{2} \tag{4}$$

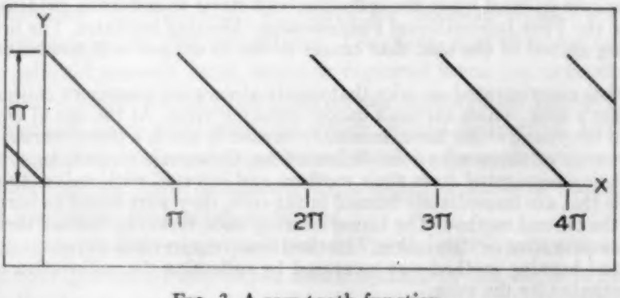

FIG. 3. A saw-tooth function.

* The Rule for differentiating absolute value functions was published in the March, 1960, issue of SCHOOL SCIENCE AND MATHEMATICS.

Differentiating this function gives

$$\frac{dy}{dx}=\frac{-|\sin x|}{\sqrt{1-\cos^2 x}}=\frac{-|\sin x|}{\sqrt{\sin^2 x}}=\frac{-|\sin x|}{|\sin x|}=-1$$

Equation (4) provides a method for defining the periodic step function which is graphed in Figure 4. The equation of the step function is

$$y=\frac{1}{\pi}\arcsin\left[\frac{|\sin x|}{\sin x}\cos x\right]+\frac{x}{\pi}-\frac{1}{2} \tag{5}$$

The anti-derivative of the step function shown in Figure (4) is given by

$$\int y\,dx=\frac{-1}{2\pi}\left[\arcsin\left(\frac{|\sin x|}{\sin x}\cos x\right)\right]^2+\frac{x^2}{2\pi}-\frac{x}{2} \tag{6}$$

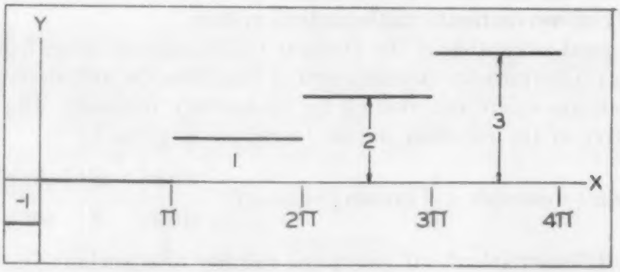

FIG. 4. A periodic step function.

CANCER STARTS WHEN INDIVIDUAL CELLS SUFFOCATE

Cancer gets its start when the individual cell starts to suffocate, evidence presented to the First International Pharmacology Meeting indicates. The first test in a living animal of the idea that cancer is due to oxygen lack was made with mice.

Scientists experimented on mice that nearly always get mammary cancer from the mother's milk, which carries a cancer-inducing virus. At the age of one year nearly all the young either have mammary tumors or are in a pre-tumerous state.

When some of these mice were delivered by Caesarean section, kept tumor-free by being segregated from their mothers and injected with radioactive food chemicals that are immediately burned in the cells, they were found to burn their food by the normal method. The tumor-bearing mice, however, burned their food by a more primitive or "glycolitic," method that requires less oxygen.

The food-burning method was measured by collecting the radioactive carbon dioxide exhaled by the mice.

Measurements on the one-year-old, pre-cancerous mice fell somewhere in between the measurements on the healthy and the tumorous mice. But even though there were no visible signs of cancer on the one-year olds, they were definitely headed in a cancerous direction.

Study of Plant Distribution on School Grounds[1]

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Plant and animal distribution has occupied the attention of naturalists through much of history. "What grows where, and why?" has always been an important question for man whether the culture was primitive or civilized, ancient or modern. Food, medicine, clothing, materials for shelter and construction, and many of the amenities of life, whether simple or sophisticated, are derived from plants and animals. It has always been important that someone knew where certain kinds of plants or animals could be found and gathered or captured, what kinds of places and conditions they lived in, and whether they could be transplanted and cultivated or domesticated.

Biogeography and ecology have ancient roots in human needs. The more esoteric concerns that grew out of biosystematics and some aspects of modern ecology have continued the interest in plant and animal distribution not only on a grand scale but also in terms of patterns of local occurrence. It is obvious that school grounds offer laboratory conditions only for certain studies concerning local distribution. It is not necessary that a portion of the grounds be in any sense wild, or that they be forested. A lawn, a playing field, an abandoned field or neglected weed patch, the edges of a road or a path will do for some purposes.

What is it? The first question is inescapable, "What is it?" We need names for purposes of discrimination and convenience. The problem of identity should never be avoided. A distinctive thing, process or relationship needs a name if we are to think and communicate clearly. Common names will do, if we use them consistently, or symbols like "a" "b" and "c," until we discover what others have already decided to call something. Teachers, and in some cases students, should consult local, state or regional floras for correct names, common or scientific, of plant species encountered on school grounds. Many states have weed manuals which should be helpful. Land grant colleges and agricultural experiment stations have botanists who can be consulted for identifications. This requires sending them a dried plant specimen, preferably in flower.

Where is it? The next question, "Where is it?" arises naturally if the school ground or any other small section of the earth is inspected carefully, for no one species is found everywhere. Each one is found

[1] Part of the "Open Meeting of National Committee for Natural Areas for Schools" of the Nature Conservancy, AAAS, New York, 27 Dec. 1960.

somewhere, and a little observation reveals certain correlations between the observed locations and the observed conditions of those places. There are two phenomena here: 1) that of place, and 2) that of the condition of the place.

The first phenomenon can be dealt with by observation and a general description of where something occurs, or it can be handled by the use of appropriate coordinates. Occurrence can be mapped. To some extent it can be dealt with by the phenomenon of "presence or absence" in a series of sample plots such as quadrates, strips, line intersects, etc., but in this case we need to know where the samples were taken, so the matter of coordinates is not avoided.

The second phenomenon can be studied in an approximtae way by observing the conditions of the station, that is, of the place where something occurs. Incidentally, it seems better to reserve the word "habitat" for the conditions at a place, and use a word such as "station" merely to indicate location. Just by observation much can be judged about exposure to sunlight and consequently about heat, and by using simple relative classes the soil can be saïd to be coarse, medium or fine, wet, moist or dry, loose or compact, etc. Many schools will have the means of measuring some of the conditions of the environment that make one habitat different from another. If the staff and students of the physical sciences can be interested in a project of the biologists to study plant distribution, the combined instruments and techniques of several departments can produce a comprehensive description of the various living conditions on the school grounds that can be correlated with the occurrence of the different kinds of plants.

Correlations don't tell you "why" Let us suppose for a moment that we know where certain species grow on the school grounds and that we know several things about the conditions of life of the different habitats. We still can't answer the toughest question of ecology, "Why does something grow where it does and why isn't it found elsewhere?"

In the first place we should never forget chance. A species may be absent from a certain place by pure chance. It simply never got there. Absence doesn't prove anything. Since we are speculating about comparatively small space, it is likely that reproductive structures of most species of plants get about pretty generally over the entire surface. But distribution of propagules isn't enough; conditions have to be right for their germination and the subsequent establishment of new plants. Failures one year and successes another are to be expected along with the simple chance that a propagule reaches a given spot.

However, there will be dozens, hundreds or many thousands of individuals of the different species. If all the plants that belong to a

given species seem to be limited to the compacted soil of paths, or to moist and shady spots, for example, then it is likely that the species is pretty well adapted to such conditions. Still it doesn't follow that a species couldn't grow well, or even better, in places where it doesn't occur. A species may be absent from a place because it is unable to withstand the competition of species that are even better adapted to the site, even though it would do better there if it had a chance. Simple correlations don't tell you why plants grow where they do. A high positive correlation does not mean that two phenomena necessarily stand in a cause-and-effect relationship.

It seems to me that interesting and important biological questions are beginning to emerge. What is tolerance? What is the nature of competition? What is the nature of interactions between organisms? When does a group of individuals of different species form a community, rather than a mere aggregation? An interesting question for students is, What is a weed? It is pertinent because many plants of school grounds are weeds. The correlative question is, "What biological characteristics do weeds have, i.e., what makes them weedy"? These matters lead naturally to experimentation. Part of it can be done outdoors; part of it is better brought into the laboratory. This is a point worth learning—the advantage of moving from the field to the laboratory and from the laboratory to the field in order to explore better the biological questions which arise.

Something about the narrowness or breadth of plant tolerance for different conditions can be learned on the school grounds by planting different species in different places. Seeds can be used or vegetative parts of perennial plants can be transplanted. They can be inserted into the pre-existing vegetation where they are faced with competition or they can be given a better chance by clearing small areas for them. To do it both ways tells us more than to do it one way alone, for we get a hint about competition. One thing to look for in transplant studies is the relative vigor of growth of similar plants in dissimilar places. Some species of the poorest sites may do very much better on better sites; others may not, with or without competition from plants naturally there.

More information about the limitations placed on plant occurrence may be gained in the classroom, laboratory or greenhouse by contriving experiments to test the success of plants over a range of conditions. The best way to do this, perhaps, is to attempt to vary one factor at a time, such as light intensity, moisture, or soil texture. It is not my purpose, however, to pursue this line of suggestions, but another.

Composition and structure. In looking about the school grounds we have discovered that some species are found in one place and others

in another. We will soon discover that several of the species normally occur together and others do not. Whether or not they have similar ecological tolerances over a wide range of conditions, they at least have tolerances whose ranges overlap and which, under the local conditions, allow them to grow together. The different groupings on the school grounds, let's call them communities, are probably not completely discrete. Some species will be found predominantly in one place, say in the lawn, but a few members will be found in other places also.

The composition of a piece of vegetation is simply a question of the species that compose it. But we can also recognize what has been called "typical composition." To know what is typical requires comparison of different, similar stands of vegetation. Some species may be only accidentally present in one or a few stands. Others may be comparatively scarce but typical because they are usually present in the community type. Still others are obviously important for a variety of reasons. Some may be very numerous. Some may not be numerous but are conspicuous. Others may occur in patches, whereas some are regularly distributed through the community. The local distribution may be random, or it may be more clumped or more regularly distributed than random!

Several of these features lead us to a consideration of the structure of vegetation as distinct from its composition. They can all be investigated on a school grounds.

Number. It isn't feasible to count all the members of a species and is seldom worth much effort in any case, but on small sample areas the determination of density—the number per unit of area—will reveal some unexpected results. The members of some species will be much more numerous than others, more numerous than they appear to be. The converse will be true of others. Judgment may have been influenced by size of individuals or by their conspicuousness for one reason or another, such as color, flowering and fruiting, or the shape of leaves. An examination of number can lead in several directions.

When a few small sample plots have been used to determine density, the results can be expanded to the entire piece of similar vegetation. Impressively large numbers may occur for some species—millions of individuals in one lawn, for example. This is a good time to get the students interested in application of mathematics. Suppose, for example, that instead of one set of small sample plots having been used to determine density (from which an average density has been determined and a range of densities from one plot to another) that different teams of students take independent series of samples. Questions will arise which will send the students to the school's mathematicians for help. The results of the different sets of counts aren't the same. Which

result is right? Which is more nearly right? What are the limits within which the average densities can vary if the differences are due to chance? What probable error does the mean density have? Something about the reliability of data, or its unreliability, is good to learn. Many people have never learned this. Nor have they learned, in many connections, that their individual observations form no adequate basis for generalization about a large population.

One runs into an interesting biological problem in an effort to find out something about number. What is an individual? What do you count? Many species present no problem, but all those that reproduce or spread vegetatively by stolons, rhizomes and rootstocks are only more or less individual at a given time.

Pattern of occurrence. Some species are more or less everywhere. Some species are more or less clumped. Some species are more or less associated, one occurring where another does to a higher degree than would be expected by chance. These matters can be studied. Once more let us lay out a series of small sample plots. In each plot merely observe whether a species is present or absent. Some species may occur in every sample plot. The ecologist would say they are 100% frequent. (Notice that frequence in this connection doesn't refer to density, but merely to how many of the sample plots contained at least one plant of the species.) At the other extreme some species may have been observed to be present in the vegetation (suppose we are examining a lawn) but didn't happen to get included in any of the sample plots. We might investigate that question. How many sample plots would have to be taken in order for all species to have been sampled? Would it be permissible to place the sample plots so that every species was sampled? If one selected the location of the sample plots would it "mess up" the results for other species? What is a random sample? How little work can you do and still get results sufficiently accurate for your needs?

So far we haven't said anything about the size of the sample plots other than to suggest that they be small. An interesting exercise would be to compare density and frequency data from series of sample plots that differ in size. A parallel study might compare results from sample plot series differing in number of plots. Increasing the number of the plots may have no effect beyond improving the accuracy of the estimates of number and frequency, but a change in sample plot size (area) may radically alter frequency data. Why? If the size of the sample plot is reduced to a point, there is no difference between density and frequency data. Why? If sample plots are too large, there is no discrimination between frequencies that is useful. Why? You may find that one species has a much higher average density but has a lower frequency than another species. How can that be? Some species

may have clumped distributions because of their manner of reproduction. How do plants multiply? How do they get around? How do they pre-empt space? This brings us to another matter, life-form and the "control" of a community.

Life-form and coverage. Life-form has been handled in several different ways for different purposes and I wouldn't suggest going very far along this line, but a point or two can be made regarding its role in determining community structure. For example, the life-form of grasses is usually very different from that of most other herbs. Height, branching type, leaf size and shape, position of vegetative reproductive structures, annual or perennial duration, deciduous or evergreen leaf persistence and such matters enter life-form classifications. In almost all kinds of vegetation the different species belong to a few if not several different life-forms. This influences structure in one obvious way; it usually results in layers in the vegetation. One of the results of such differences is that the coverage of a species may not be correlated with either density or frequency.

Coverage is usually estimated as the ground shaded by the foliage of plants, assuming an overhead light casts the plant's shadow directly onto the ground. Coverage is rather easy to estimate, if difficult to measure, for low-growing plants. It is important because it suggests the competitive ability of the plants which have high coverage. They must shade adversely many other plants, and it can be assumed, since they have grown so well, comparatively, that they get a lion's share of soil moisture and nutrients. Species of high relative coverage in a community often are spoken of as "dominants." This term implies more than "predominance." It suggests control of the community. If the vegetation being studied is structured in more than one layer, dominance can be considered separately for each layer, yet the superior layer has some degree of dominance over those which are lower.

The question of wider distribution. Teachers may wish, or may be stimulated by students, to extend consideration of plant distribution beyond local occurrence. The wider areas of occurrence can be looked up in appropriate manuals. Weeds may be of especial interest because many of them are exotic and their distribution has been facilitated by man. In other words they have been imported by man, mostly inadvertently. This may give an added opportunity for inter-disciplinary cooperation. The historians may help out by suggesting routes of human movement and times and means of conveyance of weed seeds from Europe, Asia, and elsewhere to the United States and, ultimately, to the local area of the particular school.

The generation of student interest. Any of the preceding suggestions

for fuller use of school grounds, including any more natural areas than have been discussed here, require interested teachers and, in most cases, interested administrators. Granted favorable circumstances, several things can be done to promote student interest. Perhaps a student biology or natural science club could become interested in some of the ramifications of study and action that lead off from the school grounds and class work. A herbarium could be started and added to by class after class. Student and class records could be kept so as to accumulate over the years and provide student interest in comparative data. Correspondence might be initiated between classes in different schools (even in different states) which are undertaking related projects. Photographic and other records will, over time, allow for study and discussion of change. The dynamism of vegetation is something worth learning about, in any case.

Conclusion. There are several possibilities for biological studies on school grounds that seldom are exploited. Natural areas, that is areas undisturbed by man, are not necessary for such studies. Some of these studies, although biological in nature or emphasis, may be of interest to other subjects of the curriculum and in favorable schools would profit by cooperation of the physical sciences and mathematics. I believe, also, that some of these experiences can have general meaning, especially those that raise questions about the limitations of data for generalization and the nature of competition.

ELECTRICAL EXPLOSIONS USED TO SHAPE METALS

Underwater electrical explosions are used in a new process to mold hard-to-form metals such as titanium, stainless steel and tungsten.

The new process, described as "capacitor discharge electrospark forming," is under development at General Electric Company's General Engineering Laboratory. It makes possible the saving of millions of dollars a year in the working of these difficult metals.

In the process the metal to be shaped is placed in a die underwater. A built-up of electrical energy produces an explosion that directs high-intensity shock waves against the metal to be formed. The impact of the shock wave causes the metal to take the shape of the die immediately. Removal of air from the die is necessary to prevent irregularities on the metal's surface.

The need for TNT, dynamite or other chemical explosives in forming the metals is eliminated by the process. Electrical potentials up to 35,000 volts are used now, but eventually 100,000 volts or more will be used.

Manufacturing aircraft and missile parts will be greatly simplified by this process. Metals thus far successfully shaped include niobium (or columbium), molybdenum and certain beryllium alloys in addition to titanium, tungsten and stainless steel.

The fact that the forming is done at room temperature without preheating is a considerable advantage. Metal pieces up to ten inches in diameter and one-sixteenth of an inch thick have been processed in this manner. It is expected that missile sections ten feet or more in diameter and one inch in thickness can be formed by the process.

Laboratory Safety

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Increasingly teachers of laboratory science in the secondary school and college are being asked an important question by industrial laboratories into which their graduates go: Can you afford to continue neglect of safety education? The implication is clear: the real world of business is much more greatly concerned over safety than is the preparatory work of the schools.

Increasingly, school administrators at the secondary school level are seeking more insurance coverage for accidents in laboratory and elsewhere, but damage suits by parents, such as the celebrated school bus case in Kane Co., Ill., indicate that such school coverage is often inadequate. Many times it applies only to travel to and from the school by participating team members, and is not a policy to cover laboratory injury, maiming or death. Until 1959 even our largest college-population state did not protect professors of science against suit from students injured in their laboratories, with the consequent result that every professor had to carry his own protection in some form of insurance. In plain words, safety has been beneath the notice of science teachers and administrators.

Protection, in the form of insurance, is more and more costly. One human life, in the case of auto and air accidents, has risen in value many-fold in the last 3 decades as a result of court awards. Automobile drivers who used to carry $10,000 coverage per individual injury or death, now carry up to $350,000 per individual. Likewise, school authorities are finding insurance policies increasingly expensive to give adequate protection. The value of a lost eye or a damaged hand is far greater than before World War II.

Statistics on injuries (reported in terms of man-hours, e.g., 1 injury per 100,000 man hours) for laboratory accidents are almost lacking. To begin with, there is no agency that regularly collects these data. Further, reportability is not complete in those few schools and universities where laboratory accidents are tabulated; although a cut small enough to require only a bandage from the teacher's first aid kit ought to be reportable as a sign of safety-program failure, such reports are never made unless a safety-drive is in progress. Industrial laboratories wherein semi-professional technicians work have reported from 1 to 24 accidents per 100,000 man hours of laboratory work, so we can guess that in school situations where the student is unused to the new techniques and apparatus, the rate will be far higher. Even if a broken thistle tube jammed into a wrist by inept manipulation requires medical service to remove the glass particles,

or if a cut becomes infected and requires medical treatment, there is usually no place in which such data are collected.

With the current growing sense of professionalization among teachers and professors of science, preventive measures are found more and more often. At a recent meeting of 48 chemistry teachers from the 14 counties in the northwest part of Ohio, seven reported that use of either safety glasses or face masks was mandatory in certain experiments in their high school laboratories. The new chemistry laboratory at Sylvania, Ohio, high school is equipped with both safety shower and fire blanket, although the chemistry teacher (with an industrial background) had to explain to architect and builder what such devices were. Obviously, in previous high school constructions they had not encountered such installations. Various types of fire extinguishers for physics and chemistry laboratories are the exception rather than the rule. They are always found in a school's labs where some harrowing accident has previously occurred.

The writer, in visiting 6 new high schools and their science labs, recently noted that in only one were there individual fume vents for noxious gases, four having a small fume hood (in two cases the fan was not connected, however) and one new laboratory had no fume arrangements. In all cases electrical and water outlets were close enough so as to cause a serious problem if there were uninsulated electrical connections. Potential hazards which abound in new buildings, are literally rampant in older laboratories. A general science teacher with minimal chemistry training was even generating chlorine gas, as a demonstration, without any arrangement for removing the gas from the classroom—obviously his training had not included sufficient safety-training to make him see the danger involved. He thought of chlorine as innocuous because his wife used it as a bleach.

Faulty safety training in preparation, inadequate built-in protections (both in masks or glasses, and in equipment installation) in laboratory design, and incomplete insurance coverage for accidents notwithstanding, science teachers believe they are including safety in their instructional program. An opinion survey of 17 physics and chemistry teachers taken at random indicated that they felt they had a good lab-safety program; when asked what they did to achieve it, all but one gave as the sole criterion: "Our first laboratory lesson is on safety." The other one said, "I cite at the beginning of each experiment the safety precautions to be observed," but inspection of his laboratory during a work period indicated that the perimeter arrangement was so sparing of freeway space that a student aflame would have had difficulty in reaching a shower or fire-blanket even if such had existed.

In all the newer programs (CHEM, CBA, PSSC, AP, etc.) laboratory activities are planned from 2/3 to 3/4 of the total allotted time, which means more man-hours of laboratory exposure. Teacher-training institutions must make it a part of their curriculum to include considerably more work on safety-consciousness of science teachers, including first-aid training. Science-laboratory-design specialists must increasingly study built-in protection from fire, electrical shock, radiation, gas inhalation, etc. But most of all, each of us in the field must re-examine from the total-safety standpoint every portion of the lab, the student's experiments, and our total assessment of protection to insure that the increased laboratory programs will not be hampered or curtailed by an increased accident rate, with its possible horrendous effects.

FEW SUPER-GIANT GALAXIES SEND OUT RADIO SIGNALS

The super-giant galaxies, huge star systems containing millions upon millions of stars, are believed to send radio waves forth into space for only a very limited part of their lifetimes. Although all large clusters of star systems contain super-giant galaxies, only very few of them are radio-galaxies. The radio emitting activity of such galaxies must be a short phase in the evolution of such systems.

SEEK WAYS TO GET MORE OIL OUT OF WELLS

A higher rate of recovery from oil underground wells is the aim of a three-year program at the University of California.

Sometimes as much as 80% of the reserves remain underground after the pumping is finished and the derricks are dismantled.

Petroleum engineers have long looked for another method which could bring up the remaining oil not recovered through the traditional pumping process.

One such method is to flush out the oil with another liquid, but a number of basic chemical and geological problems have to be investigated in the laboratory before the flushing technique can be used in the field.

In trying to flush oil out of the ground, the flushing or pushing liquid is almost always less viscous or more fluid than the oil. The pushing "piston" may be a natural gas, which must be separated from the oil by a "slug," or band of propane to keep the gas and oil from mixing.

However, in certain porous earth layers the pushing process becomes unstable, causing the band to break down and the gas and oil to mix.

The major purpose of the research will be to discover under what conditions such instabilities in the flow process will develop. The fundamental studies may lead to important future applications, mainly in the secondary recovery of oil. Other uses may lie in protecting underground fresh water wells from encroaching sea water along the coastal strips, and in a variety of chemical engineering processes.

The Language of Mathematics

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The concepts in mathematics bear such resemblance to the parts of speech in English that mathematics may be said to have a language of its own. The alphabet of numbers, symbols, and signs; the nouns, verbs, and other parts of speech parallel rhetoric. Their histories resemble each other in the introduction of terms; the loss of some through disuse and the adaptation of a choice few. The history of mathematical concepts deserves further examination, for it might be said that the history of mathematical symbols is the history of the language of mathematics.

Alphabet—History of Numbers

Since earliest times man has found it useful to count objects. The primitive method of counting on fingers and toes gradually paved the way for the use of stones and finally symbols to represent increasingly larger amounts.

Many peoples contributed to the development of numerals. The Babylonians carved cuneiform, or wedge-shaped symbols into stone tablets. One of the many methods of the Ancient Greeks employed the initial letters of number names to represent numbers. The famous Egyptian hieroglyphics, or picture-writings have been used for modern mathematical symbols. The Romans were the first to use the seven characters: I, V, X, L, C, D, M for their numbers. They also introduced the subtractive principle, e.g., IV or CM. The Hindu Arabic number system the commonest one in use, gradually developed a system which included place value and the use of zero.

History of Signs and Symbols

The development of signs and symbols is more recent than the development of numerals. The sign for addition (+) originated in Germany in the fifteenth century. It was called "plus" as a short form of "surplus." The sign for subtraction (−) originated about the same time. Oughtred introduced $\times$ for multiplication in 1631 and Rahn originated $\div$ for division in 1659.

Descartes introduced the use of letters from the beginning of the alphabet for knowns (a, b, c, etc.) and the use of letters from the end of the alphabet for unknowns (x, y, z). In 1866, Reye proposed a plan for using capital letters (A, B, C) for points, small letters (a, b, c) for lines, and Greek letters (α, β, γ) for planes. The latter are now used for representing angles.

Forms of Symbols

Cajori, a specialist in the field of the history of mathematics, divides the forms of symbols into two main groups: primitive forms and incorporative forms. The first group he subdivides under three headings: abbreviations, pictographs, and ideographs. Many symbols originated as the abbreviation of words. Later, some of them (their ancestral connections being forgotten) assumed decorative forms. Examples of this type are: $+$(et), π (periphery of a circle of unit diameter), $\int$ (summation), d (differential), i (imaginary), log (logarithm), lim (limit), $\sim$ (similar), and the trigonometric functions: sin, cos, tan, etc.

Pictographic or picture symbols have found wide acclaim. Examples of this type are: $\odot$ (circle), $\triangle$ (triangle), $\square$ (square), $\|$ (parallel), $\varparallelogram$ (parallelogram). The last type of the primitive forms is the ideographic or arbitrary symbol. Examples of this type might be $\times$, $\div$, ( ) (aggregation), $\therefore$ (therefore), $\because$ (since), $=$, and letters (not abbreviations) representing numbers or magnitudes.

Incorporative forms merely represent the combination of two or more mathematical ideas or symbols, for example: $\int_a^b$, ${}_nC_r$, $\lim_{x\to a}$, $f(x)$. It can be easily seen here that a whole concept which would otherwise necessitate the use of many words can be precisely grasped by a symbol.

Nouns

Having established the basic alphabet of symbols used in size language, the next step will be the study of the nouns, verbs, and other parts of speech. The nouns of mathematical language are simply numbers or letters denoting quantities. Collective nouns, such as club, herd, etc., correspond to the incorporative symbols mentioned earlier, e.g., a^n, ${}_nC_r$, $\int_a^b$.

Verbs

Many and varied are the verbs of mathematical language. All of the verbs of size language are transitive; that is, they act on another. $\times$ and $-$ are called "operators." They show the mathematician what the noun does. At times the verb is not present but is implied, e.g., ab means $a\times b$.

Hogben makes two broad classifications of mathematical verbs: those depending on their relation to each other and those depending on their relation to the rest of the sentence. The first type he subdivides into verbs of active and passive voice. $7-4=3$ might be read in the active voice as "From 7 take away 3 to get 4" while the passive voice might be translated: "What number has to be added to 3 to get 7?" Another example might be $2^5=32$ translated into active voice: "Multiply five 2's together to get 32"; whereas $\sqrt[5]{32}=2$ trans-

lated into passive voice might be "What number, when multiplied by itself five times, gives you 32?"

Verbs depending on their relation to the rest of the sentence are classified as reflexive, or commutative, and noncommutative verbs. $3+4=4+3$ is reflexive. Its parallel in rhetoric would be a statement such as: "I wash myself when I get up" which may be restated: "When I get up, I wash myself." $3/4\neq4/3$ and $3-4\neq4-3$ are examples of non-commutative verbs. A parallel in rhetoric would be: "Take this letter to the post office" which certainly is not the same as "Take this post office to the letter." Synonyms also may be used in mathematic language, e.g., $3/4=3\div4$ as "to talk with" means "to converse with."

Inverse opeators are an interesting ramification of mathematical verbs $+$ and $-$ are inverse, as are $\times$ and $\div$ because subtraction is is the opposite operation of addition; division is the opposite operation of multiplication. An inverse operator placed before a corresponding operator cancels the meaning of the latter, e.g., $4+3-3=4$, $\sqrt[3]{5^3}=5$, or the antilog of log of $5=5$. A parallel in rhetoric of inverse operators would be the phrase "I deny that I assert." Related to the concept of inverse operators is the idea of two negatives making a positive, e.g., $-(-7)=7$, as rhetorically, "I have not not had lunch" means "I have had lunch."

Other Parts of Speech

There are many other parts of speech in number language. The ellipses used in the imperative: "(You) come if (it is) possible," provides simplicity and brevity as the omission of the coefficient does in: $(1)x^2+(1)x+1=(1)y$ when the (1) is understood. Besides the verbal synonyms mentioned previously, there are several other types of synonyms. One kind, rather a quasi-synonym, is found when there are two meanings for one symbol, e.g., *dx* has a different meaning in algebra than it has in calculus. Another type is seen when there are two symbols for one meaning, e.g., $\sqrt{10}=10^{\frac{1}{2}}$. Some critics consider these types defects in the size language. Their argument is that these synonyms necessitate learning two symbols for one meaning, or investigating the context to find the precise meaning of a symbol. Other mathematicians hold that it is advantageous for language to have different symbols for one meaning, since some forms of expression are more easily manipulated than others, e.g., the multiplication of two numbers by the addition of their exponents.

Another possible source of confusion is two identical numbers which are used in different ways in two related symbols, e.g., $10^2\neq2^{10}$. In a problem of this sort, the mathematician must note that in 10^2, *2* acts as an operator and *10* as a number, while in 2^{10}, *10* is an operator and *2* is a number. This difficulty is not as acute as the corresponding

defect in rhetoric since the *2* or *10* when used as an operator is put into an unusual position and printed or written in smaller type. The difficulty involved in interpreting a parallel rhetorical statement is greater: "For sale: a baby grand piano by an elderly woman, with carved mahogany legs." This sentence may be clarified with a diagram, just as a difficulty in size language may be straightened out with a graph of the figure or equation.

There are no interjections such as "oh" and "ah" in size language. There are modifiers, however, such as the *3* in $\sqrt[3]{10}$ or the $'$ (prime) in A'. These correspond to the adverbs and adjectives of grammar. The latter are used to modify or particularize nouns and verbs.

Gerunds combine the characteristics of nouns and verbs. The symbol -3 for a negative number of $\sqrt{-3}$ for an imaginary one parallel "walking" and "eating" or any other such combinations of nouns and verbs because a mathematical noun, 3, is combined with a mathematical verb(s) $\sqrt{\ }$ and $-$. Finally, the conjunctions of size language, $\therefore$ (therefore) and $\because$ (since), correspond to the "and" of rhetoric.

Sentence Structure

This brief sketch of the parts of speech of mathematical language should advance a clearer understanding of the mathematical sentence: the equation. The equation is unique because there is only one structure used: the left-hand side and the right-hand side, which are separated by the equality $(=)$ sign. There are two main types of sentences: the declarative, which states a fact, and the interrogative, which asks a question. The identical equation corresponds to the declarative sentence in stating a mathematical fact, e.g., $3(x+y) = 3x+3y$. The conditional equation, similar to the interrogative sentence, asks a question(s):

1) Is this relationship ever true?

2) If so, what value or values must the symbols which appear in it have in order that it may be a true relationship? The equation $3x=6$ is true when $x=2$.

Common defects in everyday language are repetition and redundancy. Such verbosity is not allowed in size language. Two techniques which remove this problem are cancellation and the collecting of terms. For example,

$$\frac{16x^3y^2}{4x^2y^2}$$

may be reduced to yield $4x$. $12a^2+3a-7a^2+6-4a+5$ may be rewritten after collecting like terms as $5a^2-a+11$.

Idioms are a problem to most students of foreign languages. Such phrases or sentences do not make sense simply by looking up the words in the dictionary. (However, when a person becomes fluent in the use of a foreign language, he immediately grasps the correct meaning of the idioms used.) Mathematics appears incomprehensible or extremely difficult to the young student until, working step by step, he becomes famiiiar with mathematical notation and finds that solving problems is merely applying the fixed rules of grammar. Understanding mathematics is not a special gift given to a few people.

The language of mathematics, like a foreign language, becomes easier with practice or use. Its characteristic simplicity, practicality, and precision combine to form a most versatile tool in the hands of mathematicians. Its use extends from everyday calculations, through grade school and higher education, to the fields of physics, astronomy, and engineering.

SPARE TIME QUIZ

If a piece of paper $8\frac{1}{2}'' \times 11''$ (letter size) three thousandths (.003) thick could be folded 50 times, what would be the height of the folded paper?

Also, what size paper would be required, if folded 50 times, to come down to letter size?

Regarding the first question, guesses have ranged from $\frac{1}{4}$ inch to several feet. A college professor of physics guessed $3\frac{1}{2}$ feet.

Astounding enough, the answer is approximately 53,200,000 miles, or over 57% of earth-to-sun distance 93,000,000 miles!

Folded 23 times, the paper pile would top the Empire State Building by 900 feet! At 42 folds the paper pile would be abreast of the moon, 237,837 miles from the earth!

The answer to the second question is approximately 26,100,000 square miles, or equal to the combined areas of Africa and both North and South America!

Taken from
Philadelphia Evening Bulletin
August 1, 1961

EARLY MAN'S FIRST BONES OF HAND AND FOOT FOUND

The first bones of a foot and a hand of early man at Olduvai in Tanganyika, East Africa, have been excavated.

The fossil remains of a large part of a left foot, six finger bones, fragments of a skull, some teeth, two clavicles and two ribs have been found. The find was made close to the spot where Dr. Leakey in 1959 discovered the first remains of the Nutcracker man, or Zinjanthropus boisei, a primitive man who lived more than 600,000 years ago.

That Nutcracker man was a true man seems certain from the presence of tools found with his remains. Included in the new find were remains of animal fossils, many of them new to Olduvai and believed to be new to scientists.

The presence of a remarkable tool for working leather indicates that this early man possessed a certain amount of culture and ingenuity.

A New Look for Science Education in Iowa

T. R. Porter, Chairman
Science Area Committee for Iowa,
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The new curriculum procedures and philosophy for Iowa have been developed by a committee with varied experience and training. The following are directly represented: elementary, junior high and senior high school teachers; school administrators; science consultants; college and university science faculties; and teacher training programs. Each member of this committee is, in turn, chairman of a committee of classroom teachers who is producing the curriculum materials for a given area or grade. Approximately sixty people are involved in preparing the new science materials.

The curriculum will have continuity, kindergarten through grade 12; emphasize development of concepts by experimentation; emphasize breadth and depth rather than the continuous spiral approach; take into consideration that young children can understand much more science than adults have believed possible; include health, thus eliminating need to include this in high school biology; include enrichment provisions at all levels; and provide ample opportunity for pupils to become directly involved in science through carefully planned activities.

Much of the subject matter has been placed at a lower grade level than before. Therefore, implementation of this program will be critical. Plans are being made for in-service programs whereby parts of the new curriculum will be demonstrated. This will be followed by an opportunity for supervisor and teachers to perform many demonstrations and experiments described in the curriculum guides. A series of films is being made which will combine content and method to show the classroom teacher how he might proceed in a given area.

It is difficult to plan an adequate program at the state level because of the great variation of the schools from small to large and urban to rural. These problems have been given careful consideration and it is agreed that there should be a hard core in the new curriculum which would be required of all with enough suggested variations so the program could be easily adapted to meet the local needs and conditions. Thus, the new science curriculum should be easily adapted to fit, a 6-2-4, 6-3-3, or 8-4 organization as well as to allow for a variation of topics as to their order, enrichment, and prerequisites. The course content will be planned so there will be continuity regardless of the school organizational pattern or course sequence. The approach will be a problem-solving-activities (or action) one which will in-

volve all of a given class and encourage thinking and reasoning with concepts considered, rather than fact-for-facts sake. There should be better continuity, less overlapping and gaps in the new program, and it should be practical for each school regardless of the number of tracks in its curricular organization.

Many requests from schools have been received asking the committee for an outline of the topics and their grade placement. Since many schools in Iowa already have active (local) curriculum planning committees, a tentative outline will be presented here. Each Production Committee will construct resource units; list references, basic equipment and supplies needed; suggest prerequisites (where such a suggestion might be helpful) and enrichment activities; and show how to relate to the rest of the curriculum. Before this is presented in final form, pilot schools will be selected to try these materials and evaluate them. Science is an ever-changing field and therefore there is no final, static science curriculum. It must be brought up-to-date periodically if it is to keep pace with the developments of this age.

This program is also being prepared to be of greatest use to the teacher based on suggestions from many teachers and administrators. Emphasis will be on the application of the concepts taught to develop an understanding of the environment, to learn methods of inquiry, and to discover ways to find and verify knowledge. The following is a tentative outline of the planning of the Science Area Committee at this time.

The K-3 Production Committee has made a tentative proposal of these units and their suggested grade placement:

A. *The Universe*

K—The sky
1—The sun and stars
The moon
2—Nothing
3—Movement of earth and moon

B. *The Earth*

K—Seasonal Changes
1—Air and weather
2—Air temperature affects life (Ecology)
3—Changes in surface of earth

C. *Physical and Chemical Forces*

K—Toys and machines
1—Machines
Magnets
2—Simple chemical and physical changes
Sound
3—Basic Chemistry
Magnets and electricity

D. *Living Things*

K—Pets
1—Classification of plants and animals.
(Probably limited to higher groups)
2—Basic animal needs
Parts (structure) of plants
Requirements for plant growth
3—Plant and animal adaptations
Life cycle of insect

E. *Man's Place in a Changing Environment*

K—Nothing
1—Nothing
2—Requirements for good health
3—Germs and disease

The above listing may be changed after trial in the pilot schools this spring. An effort will be made to develop an understanding of basic concepts related to the necessities for life, variations of living organisms, and others. This will help avoid teaching facts-for-facts sake with no thinking or reasoning on the part of the children.

The Production Committee for Grades 4-5-6 will also prepare resource units to be evaluated in selected pilot schools during the spring of 1961. This group has met with the K-3 and Junior High School Production Committees in order to correlate their work. The tentative outline presented here is subject to revision after evaluation.

Fourth Grade:

1. Physical structure of plants
2. Classification of plants (Lowest to highest forms)
3. Simple Machines (Basic concepts of work and energy in relation to machines)
4. Static Electricity, electro-magnetism, and communications devices
5. Aircraft
6. Meteorology and Climate
7. Astronomy
8. Human organ systems: Skeletal
   Muscular
   Integumentary

Fifth Grade:

1. Reproduction of plants
2. Physical structure of animals
3. Classification of animals
   (Lowest to highest forms)
4. Conservation
5. Balance of nature (Ecology)
6. Kinetic theory of structure of matter
   Changes in state
   Heat
7. Geology
8. Human Organ System: Respiratory
   Circulatory

Sixth Grade:

1. Reproduction of animals
2. Physics—sound
   electricity
   light
   physical measurement
   aircraft
3. Chemistry—introduction to simple chemical changes
   introduction to simple periodic chart
   atomic structure
4. Meterology—formation and types of precipitation
   evaporation
   weather instruments and charts
   forecasting procedures
5. Astronomy—beyond the solar system
6. Human Organ Systems: Digestive
   Excretory
   Nervous

An effort has been made by the Junior High School Production Committee to plan a curriculum which will serve as a cap-stone for the elementary science program as well as prepare the pupils for the senior high school science courses. Structure and function considered in the elementary grades will be more closely related and given greater depth. Space will not permit a detailed description of this curriculum but it is hoped that the brief description will give the reader and indication of the thinking of this committee.

Seventh Grade:

1. Matter: States of matter, atomic nature, molecular nature, electron theory, and molecular forces.
2. Plants and Animals: Cell physiology, life cycle, reproduction (asexual and sexual), genetics, evolution, identifications and classifications.
3. Geology: History of earth, fossils; the changing earth rock identification methods, the earth's wealth (non-renewable resources), conservation, and wealth of the sea.
4. Meteorology: Atmosphere—make-up, gases of, density, temperature changes; air pressure—pressure systems, wind patterns; temperature; storm areas and weather forecasting.
5. Astronomy: The sun—energy source, size, importance; earth-seasons, day and night, measurements; beyond the solar system; the space frontier.

Eighth Grade:

1. Human Physiology: Man as highly complex organism; diseases—causes, defense mechanisms; stimulants and depressants—effects, control mechanisms, kinds; first aid (basic); reproduction, fertilization, embryonic development.
2. *Energy:* Types, law of conservation of energy, energy forces, transformations, Einstein's theory, measurements.
3. *Electricity:* Nature of, kinds, electron theory, measurements, electric cells, production.
4. *Measurements:* English and metric systems, instruments, units, conversion of systems.
5. *Mechanics:* Kinds of machines, machine advantages, problems, machine age.

The Biology Production Committee is developing a course of study which will be compatible with that of the Biological Sciences Curriculum Study and will not be out-of-date by the time it is available to the schools. Tentative plans include the following general areas:

1. *General biological principles* (introduction)
   Study of a biome, specific group of biome, examples of specific group. Cell, tissue and introduction to microscope.
2. *Nature of protoplasm*
   Review of composition of matter, chemical and physical changes in protoplasm, radiation and its effects on DNA and the cell, radiation sickness.
3. *The open dynamic system*
   Photosynthesis, transpiration, respiration, and diffusion.
4. *Body metabolism*
   Digestive system and nutrition, circulatory system, excretory system, endocrine system and related hormones.
5. *Microorganisms*
   Representative microorganisms, body's methods of natural defense, man's invented methods of defense.
6. *Behavior and learning*
7. *Genetics and heredity*
8. *Reproduction and development*
9. *Evolution of life*

Two national committees are developing curricular materials for high school chemistry, the Chemical Education Material Study[1] (known as CHEM) and the Chemical Bond Approach Project.[2] The Chemistry Production Committee has developed a course of study which will not be out-dated by the work of either of these groups.

1. *States of matter*
   Gas laws, molecular attraction and the liquid state, the crystalline state, the structure of crystals
2. *Atoms and molecules*
   Atomic theory, molecular structure, bonding, and energy changes
3. *Common gases*
   Hydrogen and the atmospheric gases
4. *Formulas and equations*
5. *The periodic table*
6. *Properties of common elements and their compounds*
   The halogens, sulphur and phosphorus, carbon, alkali metals, heavier metals, and transition elements
7. *Water and solutions*
   Water as a substance, solutions and their peculiar properties
8. *Ionization and ionic solutions*
9. *Electrochemistry*
10. *Equilibrium*
11. *Carbon chemistry*

This outline presupposes some previous knowledge of chemistry such as atoms, molecules, etc. which has been included in the curriculum earlier. Possible additions, included for enrichment or otherwise, would be a review of the metric system, ratio and proportions;

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[1] Headquarters—Harvey Mudd College, Claremont, California.
[2] Headquarters—Earlham College, Richmond, Indiana.

nuclear chemistry which might be included under "2" above as a special enrichment section and would emphasize radiation with special stress placed on precautions, dangers, and uses.

The Physics Production Committee is developing curricular materials for physical science, traditional physics, Physical Science Study Committee physics, and advanced science. The advanced science course is planned for those students who have interest and ability for further work in individual research and problem solving techniques. It is not planned as an advanced placement course but to develop further the scientific approach. The tentative outline follows.

1. Detailed discussion of project requirements of course.
2. The Log-Log slide rule. All scales on a K and E Log-Log duplex deci-trig rule would be learned.
3. Quantitative aspects of beginning college chemistry. Review and extension of basic atomic and molecular designations, Dalton's Laws of partial pressure, derivation of Graham's Laws of diffusion from kinetic energy, solution strengths, weight and volume problems by the "Factor Method," equilibrium reactions, solubility products.
4. Historical study of atomic energy. Democritus and Aristotle through the work of Dalton, Bacquerel, the Curies, Thomson, Millikan, Rutherford, Bohr, Aston, Bainbridge and Chadwick. Modern means of nuclear studies based on Coulomb forces.
5. Physics and chemistry of modern biology.
6. Unanswered questions in science.

The science curriculum will be prepared in a form most useful and practical to the teacher. Each grade or course will probably be in a separate booklet which will also include suggested activities, references, materials and supplies, visual aids, and teaching suggestions. It is anticipated that these guides will be revised periodically so the Iowa science curriculum will keep pace with the new discoveries and ways to present these in the classroom.

Teacher orientation is of major concern to the Science Area Committee. Recommendations will be made which, it is hoped, will facilitate the establishment and use of this curriculum when it is available to the schools. With the fine cooperation the Science Area Committee is receiving from teachers, administrators, and others it is hoped that the major part of the science curriculum will be ready for the schools of Iowa in the fall of 1961.

METEORIC SHOWERS INCREASE DENSITY OF EARTH'S ATMOSPHERE

The meteoric showers that occasionally rain down from the sky increase the density of the earth's upper atmosphere.

Meteoric particles streaming into the upper atmosphere heat its lower layers, causing a rise in the density of the thin air 200 to 400 miles above the earth. The density may increase as much as ten percent.

A Note On Fermat's Two-Square Theorem

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Fermat demonstrated that all primes, excluding 2, may be divided into two classes: those of order $4n+1$, leaving a remainder of 1 when divided by four, and those of order $4n+3$, leaving a remainder of 3 when divided by four (the prime 3 is included in the second class). First class primes are 5, 13, 17, 29, 37, 41, . . . , and second class primes are 3, 7, 11, 19, 23, 31, ...

First class primes may be formed by finding sums of two integral squares. One example is 41, which is equivalent to 4^2+5^2. Second class primes may not be expressed in such a way.

Two mathematicians, G. H. Hardy and Eric Temple Bell, wrote in glowing terms of this great theorem—Hardy of its beauty and fame—Bell of Fermat's method of proof.

What I wish to show here is a method for writing primes wherein they are sequentially distributed according to class. Such classification may be accomplished without actual division; in fact, *addition* by four, accomplished with the aid of an adding machine or other calculator or computer is all that is necessary. By using this tabular distribution of primes some teachers may find it easier to demonstrate the theorem.

Classification of Primes

$4n+1$	*1*, *5*, 9, *13*, *17*, 21, 25, *29*, 33, *37*, *41*, 45, . . .
$4n+3$	*3*, *7*, *11*, 15, *19*, *23*, 27, *31*, 35, 39, *43*, *47*, . . .

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DUMPING RADIOACTIVE WASTES INTO SEA HOLES URGED

Radioactive wastes can be safely disposed of by dumping them in wells drilled deep into the ocean bottom.

A huge ship, especially designed for storing radioactive waste, would be used to drill wide holes in deep ocean submarine canyons. The waste material would be lowered into the hole and buried.

Buried under tons of sediment far from heavily populated areas, the radioactive wastes would pose no heat problems. The radioactive heat generated while contained in the ocean bottom layers will not erupt into a "radioactive geyser," whereas atomic wastes stored in underground vats on land can.

Readability of Biology Textbooks and the Reading Ability of Biology Students

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State and school textbook committees, administrators and teachers, who are responsible for the selection of textbooks frequently make use of evaluation scales that involve consideration of the author's qualifications and the book's organization, content, presentation, accuracy, readability, adaptability, teaching aids, illustrations and appearance (14). Generally, those who have selected textbooks in science have not availed themselves of specific information concerning the reading difficulty of these materials. The rating supplied by the publisher is often given as an estimate which, if it is near the grade placement of the subject, satisfies the publisher's purpose. However, school people must heed the warnings from the various studies of Mallinson (8) in which he concludes that "the levels of reading difficulty of many textbooks in all areas of science are too advanced for the students for whom they are written." In view of this conclusion, it is vital that readability ratings become an integral phase of the textbook selection process. Consideration must also be given to the reading ability of the students for whom the textbook is intended. Textbook selection committees, administrators and teachers tend to consider only the grade placement of the subject when dealing with the reading difficulty of the material. The dangers of this course are only too apparent to the teacher using the textbook, as obviously all students are not functioning in reading at the grade level of the subject placement. The reading achievement of the students enrolled in the course would provide more realistic data for determining the needs that are to be met by a particular textbook.

Purpose

The purpose of this study was to determine the reading difficulty level or the readability level of selected general biology textbooks, and to determine the level of achievement in reading of students enrolled in high school biology classes.

Procedure

Five biology textbooks (1, 5, 7, 11 and 13) selected by a state textbook committee were analyzed by the Dale-Chall Formula for Predicting Readability (4). Three hundred and fifty-seven students en-

rolled in 14 sections of tenth grade biology from 6 high schools in a single county area were given the Nelson-Denny Reading Test, Form A Revised Edition (12). The test data were secured during May at the end of the term during which the students were enrolled in biology.

Results

The results of the textbook analysis and the reading achievement testing are reported in Tables 1, 2, 3, 4, and 5. The tables report, for each textbook, the number and per cent of students who read: (a) one grade or more above the rating of the Dale-Chall Readability Score, (b) between the Dale-Chall score and one grade above, and (c) below the Dale-Chall score.

In discussing high school science texts Mallinson states (9) that "in order to be effective the reading difficulty of books must be at least one grade level below that of the students for whom it is designed." That is, the reading achievement of the students must be at least one grade above the reading difficulty of the book.

In examining Table 1 it is apparent that if Mallinson's standard is applied Book A readability level score makes the textbook useful to only 132 or 37% of the students in the study. Over half of the students had reading scores below the readability score of the textbook.

Table 1. Book A—Dale-Chall Readability Score 11.0

Students' Reading Scores in Relation to Textbook Readability	Vocabulary		Comprehension		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
One grade or more above Dale-Chall Score (12.0 and above)	114	31.9	152	42.6	132	37.0
Dale-Chall Score to one grade above (11.0 to 11.9)	40	11.2	34	9.5	40	11.2
Below Dale-Chall Score (10.9 and below)	203	56.9	171	47.9	185	51.8

Book B's readability score makes this textbook useful to a slightly larger group, 141 or 39.5% of the students. More than half of the student's reading scores still fell below the readability score of the book.

Book C's readability score makes this textbook useful to 151 or 42.3% of the students.

Book D's readability score makes this textbook useful to nearly half of the students, that is, 177 or 49.6% of the students.

Book E is the only textbook in the study that is useful to over half of the students. The readability score makes this textbook adaptable to 209 or 58.5% of the students.

The vocabulary and comprehension scores from Table 1 indicate that for Book A, 152 or 42.6% of the students had comprehension scores adequate for the book, while only 114, or 31.9% of the students had vocabulary scores adequate for the book. Table 2 (Book B), indicates that 168, or 47.0% of the students had adequate scores in comprehension, while only 123, or 34.4% of the students had adequate scores in vocabulary. Table 3 (Book C), indicates that 168,

TABLE 2. BOOK B—DALE-CHALL READABILITY SCORE 10.8

Students' Reading Scores in Relation to Textbook Readability	Vocabulary		Comprehension		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
One grade or more above Dale-Chall Score (11.8 and above)	123	34.4	168	47.0	141	39.5
Dale-Chall Score to one grade above (10.8 to 11.7)	31	8.7	17	4.8	36	10.1
Below Dale-Chall Score (10.7 and below)	203	56.9	172	48.2	180	50.4

TABLE 3. BOOK C—DALE-CHALL READABILITY SCORE 10.6

Students' Reading Scores in Relation to Textbook Readability	Vocabulary		Comprehension		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
One grade or more above Dale-Chall Score (11.6 and above)	138	38.7	168	47.1	151	42.3
Dale-Chall Score to one grade above (10.6 to 11.5)	30	8.4	43	12.0	38	10.6
Below Dale-Chall Score (10.5 and below)	189	52.9	146	40.9	168	47.1

TABLE 4. BOOK D—DALE-CHALL READABILITY SCORE 9.9

Students' Reading Scores in Relation to Textbook Readability	Vocabulary		Comprehension		Total	
	Number	Per Cent	Number	per Cent	Number	Per Cent
One grade or more above Dale-Chall Score (10.9 and above)	154	43.1	185	51.8	177	49.6
Dale-Chall Score to one grade above (9.9 to 10.8)	67	18.8	50	14.0	47	13.2
Below Dale-Chall Score (9.8 and below)	136	38.1	122	34.2	133	37.2

TABLE 5. BOOK E—DALE-CHALL READABILITY SCORE

Students' Reading Scores in Relation to Textbook Readability	Vocabulary		Comprehension		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
One grade or more above Dale-Chall Score (10.2 and above)	177	49.6	235	65.8	209	58.5
Dale-Chall Score to one grade above (9.2 to 10.1)	72	20.2	34	9.5	51	14.3
Below Dale-Chall Score (9.1 and below)	108	30.2	88	24.7	97	27.2

or 47.1% of the students had adequate scores in comprehension while only 138, or 38.9% of the students had adequate scores in vocabulary. Table 4 (Book D), indicates that 185, or 51.8% of the students had adequate scores in comprehension, while only 154, or 43.1% of the students had adequate scores in vocabulary. Table 5 (Book E), indicates that 235, or 65.8% of the students had adequate scores in comprehension, while only 177, or 49.6% of students had adequate scores in vocabulary.

CONCLUSIONS

The need to give greater consideration to readability in the selection of biology textbooks is supported by this study. Further, the need to obtain specific information concerning the reading ability of the students for whom the book is intended is apparent from the re-

sults of this investigation. Only one textbook in the study had a readability score that made it useful to over half of the students in the study. A study aid so lacking in usefulness is difficult to justify in selecting textbooks. The relatively poor vocabulay scores of the students in this study suggest problems in the utilization of materials in science with that field's normally difficult and technical vocabulary.

It should be emphasized that the main implication of this study lies not with specific results but with the process involved. Other textbooks and other groups of students might give different results, but the need for evaluation of both the readability and the reading ability of the students for whom the books are intended obviously exists.

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WOMEN FOUND BETTER ABLE TO STAND HOT SPACE TRIP

It would be easier for women to stand high temperatures inside a spacecraft in flight than it would be for men. Experiments show men should be comfortable in space if their skin temperature does not exceed 97 degrees Fahrenheit, which requires a spacecraft temperature of 104 degrees. Women, however, should be comfortable with maximum skin temperatures of 102 to 104 degrees, requiring a spacecraft temperature ranging from 120 to 130 degrees Fahrenheit.

Research for the Library Minded Mentally Advanced Arithmetic Pupils in Grades 4, 5, and 6

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One means of challenging the talented pupil in arithmetic is to provide opportunities for him to investigate number topics in encyclopedias, general reference books, trade books, and other books which may be found in the classroom arithmetic library. If a good number of reference sources are available, pupils should enjoy and profit from exploration of such topics as suggested below. Pupils might be encouraged to maintain a notebook especially to hold their reports. At times the teacher will likely call for oral reports and perhaps display a very good paper on the arithmetic bulletin board. The school librarian, as well as the classroom teacher, might be called upon for help in locating references as required. (A survey of the questions will reveal that several of them are general enough in nature that a number of more specific ideas might be extracted for special attention.)

A. Number system:
1. How did early man first learn to count?
2. What system of number notation was used by the Greeks?
3. What system of number notation was used by the Babylonians?
4. What system of number notation was used by the Egyptians?
5. What is the story of Roman numerals?
6. What is numerology?
7. What was the Maya Indian number system?
8. How does a numeration system with a base of 2 or 5 work?
9. What is the origin of our present day number names?
10. What is the origin of the "zero"?
11. Why are our numerals called "Hindu-Arabic"?
12. What are cardinal and ordinal numbers?
13. What difference is there between the English and American way of reading and writing numerals?
14. What is the largest possible number?
15. What are prime numbers?

B. Addition:
1. How did early man first learn to add?
2. How can a *quipi* be used for adding?
3. What is the history of the United States Census?
4. Can you explain the use of the abacus as an adding device?
5. Can you explain how an adding machine works?
6. What is meant by the "civil service" check of addition?
7. What are some "old" ways of checking addition examples? (Check of "nines," check of "elevens," etc.)
8. How can two columns be added simultaneously?

C. Subtraction:
1. How did early man do his subtraction?
2. How can subtraction be done on an abacus?

3. What are some "old" ways of checking subtraction? (What was the "scratch" method, etc.)
4. What is the "Austrian" method of subtraction?

D. Multiplication:
1. How did early man multiply?
2. How can an abacus be used to show multiplication?
3. What are some "old" ways of checking multiplication?
   a. How can multiplication be done with a "slide rule?"
   b. What is "lattice or gelosia" multiplication?
   c. What is the "Hindu" method of multiplication?
   d. How does the French peasant multiply by using his fingers?
   e. What is the "sluggard's rule" of multiplication?
   f. What is the "crossline" method of multiplying?
   g. What is the "duplation" method of multiplying?
4. What are some "lightning" ways of multiplying?

E. Division:
1. How did early man do his division?
2. What are partition division problems and what are measurement division problems?
3. What are some "old" ways of checking division examples? (What is the "galley" method of division, etc.)
4. How is division done in the elementary schools of Brazil, South America?

F. Common Fractions:
1. What is the history of common fractions?
2. What is the origin of the term "fractions"?
3. What was the Egyptian way of writing fractions? How did they add fractions?
4. What are "complex" fractions?
5. How are baseball averages computed for baseball players?
6. What uses are made of fractions in business and industry?

G. Decimal Fractions:
1. What is the history of decimal fractions?
2. What is the history of decimal notation? (How is the decimal notated in other countries?)
3. What are "repeating" and "terminating" decimals?
4. What use of decimal fractions do scientists make?
5. What is the Dewey Decimal System?

H. Measures:
1. (Clock-Calendar time)
   a. What is the history of time-telling? What were some ways of telling time many years ago?
   b. How was time reckoned by "bells" in the days of sailing ships?
   c. How did day, hour, and minute originate?
   d. What is the "24 hour" clock?
   e. What are the different time units around the world?
   f. What is the explanation of standard time; daylight saving time?
   g. What is the history of the calendar?
   h. What is the story of the Aztec Calendar stone?
   i. What is a perpetual calendar?
   j. What is the "World Calendar"?
   k. What is the "13-month calendar"?
2. (Money)
   a. What is the origin and early uses of money?
   b. What is the history of United States money?
   c. What is a mill as a unit of money?
   d. How does foreign money compare with our money?
   e. What are some interesting facts about the stock market?

3. (Instruments)
   a. What is a micrometer?
   b. How does an odometer work?
   c. What are the uses of several precision instruments?
   d. What is the history of the thermometer, rule, scale, speedometer, and barometer?
4. (Miscellaneous)
   a. Why does the Canadian and United States of America gallons differ?
   b. What are the laws in your state regulating measures and scales?
   c. What are the standard weights of containers of grains and vegetables in your state?
   d. What are some old measures no longer in common use today?
   e. What are some "unusual" measures?
   f. What is the difference in Fahrenheit and Centigrade temperature?
   g. What is the difference in *avoirdupois* pound and the *troy* pound?
   h. What is the difference in the old Roman *pound* and our *pound?*
   i. What are some arguments for and against adopting the metric system of measures?
   j. What is the difference in *exact* and *approximate* measure?
   k. What is the difference in *precision* and *accuracy* in measure?
   l. How do the mean, median, and mode differ from one another?
5. (Practical Application)
   a. How can you read a bus, plane, and train timetable?
   b. How do you read the weather report in the newspaper?

I. General:
1. What uses of arithmetic do you find in mail order catalogues?
2. What uses of arithmetic can be found in recipe books?
3. What arithmetic may be used in "want ads" in daily newspapers?
4. What are some examples of "geometry in nature"?
5. How is arithmetic used in music?
6. Who are some of the famous men of arithmetic, mathematics and what are their major contributions?
7. What are some stories of "calculating prodigies"?
8. It has been said that "one out of every seven words in books or magazines is mathematical in nature." Can you prove this statement true or false?
9. What number references can you find in your history, geography, and science books?

MANY WEATHER QUESTIONS ARE STILL UNANSWERED

Many questions about the atmospheric behavior must be answered before the weather, such as the battering series of snowstorms that recently hit the eastern United States, can be adequately controlled, the U. S. Weather Bureau said.

The most promising method for controlling the weather is to squelch the storm in its early stages. Whirling weather satellites scanning the weather patterns would provide a much better observational system than meteorologists now have for detecting storms.

The first two experimental weather satellites, Tiros I and II, have already been useful in spotting cloud patterns associated with storms when they form.

The Weather Bureau has also been conducting basic atmospheric research during the past five years in its laboratories. Highspeed electronic computers are working constantly, imitating the functions of the atmosphere.

Weather men are dealing with tremendous energies when they tackle storms. In one year, winds carry energy equivalent to about two billion atom bombs across the 40-degree latitude.

The storm that hit New York City last winter dumped about 40,000,000 tons of snow. If the snow could have been melted to rain by applying heat, it would have required the heat equivalent of 120 atom bombs.

A Microrespirometer for High School Biology*

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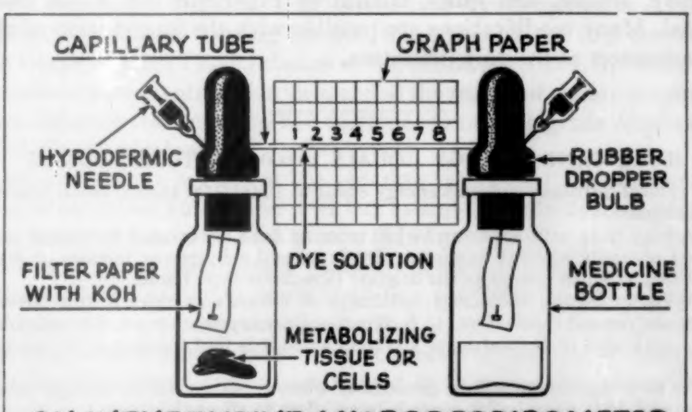
The following device is a simplification of expensive microrespirometers that have been used in classical experiments in determining gas evolution in metabolizing cells. Two glass chambers connected with a capillary tube contain, in one, the sample of material the respiration of which is being measured and, in the other, everything present in the first except the tissue or cells. The oxygen consumption of the biological material is shown by the movement of a droplet of dye in the capillary tube, while the carbon dioxide liberated is absorbed by potassium hydroxide on the filter paper.

As illustrated in the diagram, two identical medicine bottles fitted with rubber dropper bulbs are connected with a capillary tube. In a



AN INEXPENSIVE MICRORESPIROMETER

variation small test tubes could be used by supporting them in a test-tube rack. The capillary tube used has an inside diameter of 1 mm. and may be found in catalogs listed as a coagulation capillary tube. A drop of dye solution or kerosene is added to the capillary before assembling. Also a pin with filter paper is inserted into the lower rim of each rubber bulb and serves to hold the KOH. The two hypodermic

* Developed at Occidental College NSF Summer Institute with the aid of Dr. Patrick H. Wells, Dept. of Biology.

needles allow equalization of pressure as the apparatus is assembled and by gently blowing into one it is possible to move the drop of dye to any desired position. When temperature and light have been equalized, measurement may begin by removing the two needles.

The small piece of graph paper allows a record of the gas production and can be marked according to the passage of time. Many living things may be placed in the experimental side. Good results have been obtained using a piece of liver from a sacrificed animal, small invertebrates such as insects, snails, protozoans, and plants or plant parts.

To determine oxygen production from green plants (preferably aquatic plants) remove the pins and filter paper and place the plant substance in one side with equal amounts of water in each side. To provide CO_2, bubble expired air into each side for one minute.

If accurate measurement of gas evolution is desired the capillary may be calibrated in the following manner. The volume of the capillary is accurately obtained by inserting a column of mercury the length and weight of which are then accurately measured.

The specific contribution of this device lies in its use as an inexpensive, simple, and quick laboratory experience for a one hour period. Many modifications are possible with the imagination of the experimenter as the only limitation.

HURRICANE ENERGY EQUALS 10,000,000 ATOMIC BOMBS

A typical hurricane unleases energy equal to 10,000,000 atomic bombs during its lifetime.

Slashing rains with winds up to 150 miles an hour are created by energy generated within a whirling hurricane. Every second a hurricane releases at least ten times as much energy as the original Hiroshima-type bomb.

Trying to control such huge outbreaks of nature's energies is still beyond scientists' present capabilities. U. S. Weather Bureau scientists are now searching for a weak spot in the hurricane's system when it is first forming to try to control it.

One such experiment will be carried out when airplanes will fly straight into a storm and drop silver iodide crystals in an effort to affect the storm.

YO-YO DE-SPIN DEVICE WILL SLOW SATELLITES

A Yo-yo method may soon be used to slow down the spin of satellites.

The mechanism consists of two pieces of wire with weights on the ends. The wires are symmetrically wrapped around the middle of the satellite and the weights are fastened by a release device.

At a predetermined time, after the satellite has separated from the launching vehicle and is spinning in space, the weights are released and the two Yo-yo's reduce the spin of the satellite to the proper spin.

Algebra I—Eighth Grade or Ninth Grade?

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With the advent of the first sputnik there was a clamor in and out of educational circles for change. Experts from likely and unlikely places appeared on the scene. The reformer, the middle-of-the-roader, and the conservative all gave their opinions. There seemed to be widespread support for moving things down or out of the curriculum. One subject which received a great deal of attention was first year algebra, or Algebra I as it is called in many systems.

There was concern about achievement and its relation to maturity. Do 8th graders score as well on achievement tests after one year of instruction as do 9th graders? With the cooperation of a number of algebra teachers in Central Pennsylvania, we tried to get some indication of possible answers to this question.

At the end of one year of instruction in first year algebra, Form Y of the Cooperative Algebra Test distributed by Cooperative Test Division, Educational Testing Service, was administered to 5 classes of 8th Grade Algebra I and 5 classes of 9th Grade Algebra I. Six different teachers were involved. Let us examine the results of classes taught by two different teachers who had sections of both 8th grade Algebra and 9th Grade Algebra.

If we can assume in each of the separate tables that the students were of about equal ability and if we can assume that the teacher presented similar material to each group, then it would appear that the achievement scores regardless of maturity are about the same. If the test differentiates at higher levels of ability and if the groups taught by Teacher #1 were inherently more capable, then the mean scores on the tests should have been somewhat greater in the case of classes taught by Teacher #1 than those taught by Teacher #2. This was obviously not true. From the data given in the tables, it would appear that these 8th graders in the range of I.Q.'s indicated seemed to have achieved as much as the 9th graders did in Algebra I.

Also included in the testing were six other classes, three 8th grades and three 9th grades. Unfortunately these classes were taught by four different teachers. The tables indicate data on these classes. The teachers are indicated as #3, #4, #5, and #6.

It would appear here that these 9th graders of lower mental ability as indicated by I.Q. scores (Teacher #6) do not achieve as much as other 9th graders (Teacher #5) of somewhat higher mental ability. This same generalization can be stated for the 8th graders tested.

TEACHER #1

	Mean I.Q.+S.D.	Mean Test Score +S.D.	Range	Median	N
8th Grade	123 ± 12	68 ± 9	86–44	66	37
9th Grade	123 ± 6	69 ± 8	79–43	70	27

TEACHER #2

	Mean I.Q.+S.D.	Mean Test Score +S.D.	Range	Median	N
8th Grade	116 ± 7	68 ± 6	79–49	67	37
9th Grade	117 ± 9	70 ± 6	81–58	72	29

8TH GRADE
TEACHERS #3, AND #4

	Mean I.Q.+S.D.	Mean Test Score +S.D.	Range	Median	N
Teacher #3	116 ± 6	55 ± 10	72–38	53	29
Teacher #3	115 ± 5	54 ± 11	81–33	53	23
Teacher #4	126 ± 10	74 ± 4	81–60	75	34

9TH GRADE

	Mean I.Q.+S.D.	Mean Test Score +S.D.	Range	Median	N
Teacher #5	114 ± 9	64 ± 5	72–53	64	29
Teacher #6	107 ± 7	51 ± 8	68–33	50	35
Teacher #6	109 ± 8	41 ± 9	65–33	36	27

From this limited study it would appear that 8th grade students can succeed in Algebra I. However, it will be noted that no so-called low ability groups are included in the study. This would, without a doubt, be true in all cases where similar research might be undertaken. One would not expect to find less capable students in Algebra I. Hence, with a good deal of skepticism pending additional studies, we would suggest the following: Eighth graders who elect algebra or, better still, are recommended by their guidance counselors and arithmetic teachers probably will succeed as well in Algebra I as 9th graders of similar mental ability. Future studies, in order to draw more definite conclusions, should try to match students of like ability with the same teacher working under similar conditions. This preferred procedure was impossible in this study.

Science in the Junior High School

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Introduction

With the advent of atomic energy, space satellites, and supersonic aircraft, many of the problems that faced society twenty-five years ago have been completely overshadowed by the awesome possibilities unfolded by recent technological advances. Today, even small countries possess the potential for complete annihilation of the major cities in the world. Alarming possibilities of "thought-control" available through the use of new drugs and mass communication media have been suggested in Huxley's *Brave New World Revisited* (9). It is abundantly apparent that science, directly or indirectly, is of primary importance to every citizen, especially to citizens in a democracy. The question is not whether science instruction is needed; we must determine what we shall attempt to teach in the areas of science.

A carefully planned science program for grades seven through nine is of paramount importance since it is at this level that many students begin to form career preferences (17). Even more important, this period of early adolescence is a time when attitudinal changes are abundant and science has much to contribute to the formation of constructive adult attitudes, an important consideration frequently forgotten in course content planning.

The Goal of Science in the Junior High School

All elementary school programs include some instruction in science. Except for schools where curriculum planning and instruction is carefully supervised, elementary science instruction is likely to be highly variable in amount and quality. Such elementary programs are in need of study and reorganization, but this problem lies outside the scope of the present paper. It should be noted, however, that the most successful junior high science program will result in a school system where there is K through 12 planning of science and other curricula (15).

Elementary science instruction, when well done, should develop an awareness of some of the major generalizations in science, e.g., living things reproduce, matter and energy cannot be created nor destroyed, though it may change forms, etc. Earlier experiences with living and non-living things should have given elementary meanings to these generalizations and these can serve as the basis for extending the student's understanding in the junior high school (1, 5).

Science teaching should set as its goal the acquisition of major concepts. It is impossible to teach concepts without teaching impor-

tant facts. The converse is not true; it is possible to teach facts without teaching concepts (16). Such "isolated" information, frequently acquired through rote memorization, is notoriously ephemeral (3, 14, 18). Much of present-day science teaching is essentially fact memorization and this explains in part why some research studies on the value of prior course work in science indicate no relationship to success in subsequent science courses (10, 19).

Concept teaching requires careful consideration of the experiences the students will receive. Certain facts and principles must be discovered by the student as relevant to the idea or concept. Very important too, the emotional experiences associated with the concept should be as favorable as possible (20). To illustrate, let us consider the concept of the gene as a hereditary determinant. The student needs information which relates to manifest gene action, e.g., parents with brown eyes have brown-eyed children, parents with attached ear lobes have children with attached ear lobes. How can such information be acquired in a pleasant or emotionally positive manner? Are we not all curious about the appearance of ourselves and our peers? Properly approached a search for the necessary facts could be a pleasant school activity.

When it is established that certain traits apparently are inherited in a clear-cut fashion (and it will be noted that others are not) we have a basis for developing a scheme or *concept* as to how genes act. An important advance in the understanding of heredity can be made by junior high students. They will forget whether or not brown eyes are dominant to blue and similar facts, but they are likely to remember that the eye color of an individual is determined by the hereditary material of his parents. This concept can be expanded in high school and again in college. Indeed, the search for understanding of the concept of gene action is currently an active area of research in biology! It is worth noting that all of the major concepts in science are constantly being revised—the very essence of science as an enterprise is the use of old concepts to develop new and better understandings or concepts (4). The value of a concept in science is not dependent on whether or not it is "true"; a concept is valuable when it aids in devising many new concepts which explain observed phenomena (11). Science in the junior high school should begin to develop such an understanding of science, an understanding not possessed by most college science majors. The success of a science program should be measured in terms of the student's gain in understanding of the major science concepts, albeit this is seldom done.

If we accept the teaching of concepts as our primary goal and explore the most effective means for teaching concepts, it becomes immediately apparent that the plethora of details in junior high

science textbooks cannot be presented and memorized. We must choose to place the learning of concepts first; what details in the textbooks can be utilized should be brought in. Note that it is the plural of textbook that we use. No single textbook or reference source is adequate for concept teaching of science. The issue focuses, then, on the selection of major concepts to be taught, say in 7th grade. Here again, the importance of K through 12 curriculum planning enters in. In any case, the selection of concepts should consider the competencies of the teachers involved. Omission of a major concept, e.g. the role of gravitation in the solar system, is less serious than superficial coverage of a multitude of facts, the currently most common pattern of science teaching.

Planning for Science Teaching

The study of concept formation is today an important area of psychological research; obviously it would be impossible to describe the "correct" facilities and procedures necessary for teaching the major concepts of science. However, enough is known that we may take positive steps in planning facilities which will make possible learning situations appropriate and effective for concept formation.

First, it is necessary to have available resources for student contact with real science materials (12). To study electricity as an important form of energy, the students need wires, batteries, metals of various types, radio parts, motors, meters, etc. Many of these things can be obtained for little or no cost, though a new teacher would be sufficiently occupied using material already available. Adequate storage space and student work areas are very important. With such facilities students may make batteries, electromagnets, and conduct simple experiments and through these experiences some concept of how electricity is produced and how it can be utilized as a form of energy can be developed. All relevant facts and principles could be taught without these materials. It is much less likely that electricity as a form of energy will be appreciated and understood to the same extent without real experiences with electricity. Certainly no skills in working with electric devices can be learned nor is it likely that a student's emotional predisposition (e.g. attitude) toward electricity will be made favorable. Are not the latter more important?

In the life science areas, it is equally important that facilities for working with *living* things are available. Whenever possible, a wooded area or a pond on the school lot should be preserved as an important resource for teaching about living things (8). It is not likely that a student will appreciate what it means to be living unless he observes living phenomena. A textbook description of how a plant grows has a grossly different meaning for a student than an experience where

seeds are planted, young stems and leaves are marked, and differential expansions of portions of the plant are observed. The effect of different colors of light on plant growth studied by covering plants with various colors of cellophane may be equally dramatic. Not only does the student learn skills as he works with these materials, he also develops attitudes which dispose him to look more critically at an enormously important property of living things, i.e., growth. The facts, principles, and subtle relationships (13) among the facts combined with a positive emotional reaction toward the study of growth—all these fuse together in the formation of a concept which may have real significance to the individual, and we know that such concepts are not soon forgotten (3).

Facilities for science instruction should include reference sources. An abundance of these should be available *in the science room*. The student who discovers that the insect he thought was a bee looks more like a fly does not want to wait until "after school" to answer the question. Solving problems, developing ideas or concepts—the excitement of this kind of learning should not be curtailed by a lack of easily available reference materials. The competent teacher will be characterized by the resources he has in his room, as well as those in his head.

There is a widespread interest in making provisions in teaching for individual differences in student abilities. Many schemes are available for subdivision into ability groups, interest groups, and other "homogeneous" groups. Some grouping may be feasible in a school. However, accommodation for individual differences, especially for gifted students can never be effected by grouping procedure alone (6). The best single approach to accommodation for differences in abilities and interest is to focus instruction on learning of major concepts through group and independent study—an approach which allows students to begin where they are to use their knowledge and talents in expanding *their* concepts of science.

To guide students in this learning it is necessary that the teacher have extensive training in science. A minimum of 50 semester hours in various sciences would be a desirable goal.

As the student works with electricity, plants, or insects he will discern many questions which relate to his study. These questions or problems which arise are a built-in catalyst to further inquiry and the wise teacher will exploit this motivation. Student projects should grow out of regular class activities. These projects should be "problem solving" in nature and if class activities are oriented toward building understandings, worthwhile projects will be a natural outcome. The creative student may sense some curious (to the teacher, at least) problems, but this kind of problem is the type which in

later years may lead to significant advances. There is evidence that creative children are not popular with teachers (6); admittedly such children can be a challenge, but should we not encourage creative expression? (2, 5, 17) Facilities for science teaching should definitely include some type of provision of independent student activities.

Summary

We began with the premise that science is important in contemporary society. We extended this premise and indicated that science is a process by which new knowledge and new concepts are obtained; therefore, the development of some ***understanding*** of the major concepts in science *is* the study of science. The educational research evidence indicates that certain facilities and teaching practices are effective and necessary for teaching of concepts. The skills, emotional experiences, subtle observations and cues (13), and pertinent facts associated together during study of science phenomena are necessary for learning of concepts. A science program which results in high student "achievement" on tests of facts alone is not sufficient; we must ask that the students also acquire understandings. Fortunately, what little evidence is available suggests that students who have been taught with an emphasis on concept formation, as contrasted to those taught with emphasis on fact learning, learn as much or more facts and these facts are retained longer.

It has been said that the major problems in the world today stem from man's inhumanity to man, and that this inhumanity is due to lack of understanding. Those of us concerned with education must accept the challenge that faces us. How does our science program, social science program, or art program develop an appreciation for the worth of human endeavor? Is this not the purpose of education? The well conceived, well executed science program will be one that helps young people to know and appreciate those major concepts of science which help man to understand.

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FORMATION STEPS FOR PRIMITIVE CHEMICAL FOUND

Hydrogen cyanide, ammonia and water are believed by many scientists to have been present on earth at its early stages and over millions of years to have combined into the kind of organization required for the origin of life.

POLIO IMMUNITY INCREASED WITH LIVE ORAL VACCINE

Percentages of antibodies, or protective substances, have been found greater for 350 New Haven preschool children receiving Sabin oral live poliovirus vaccine than when they received Salk killed vaccine.

The Yale Poliomyelitis Study Unit tests demonstrated that the Sabin oral poliovirus vaccine is effective and acceptable.

The 350 preschool children given oral Sabin vaccine were followed for six months following the trial period, and no illnesses or any reactions were caused by the type of immunization.

Despite prior immunization with Salk vaccine, tests on a few drops of blood from the finger showed 22% were still lacking antibodies against all three poliovirus types, and the number of children protected against any one type ranged between 39% and 57%. All had received at least one Salk injection, and 80% of the children had received three or more doses before receiving the oral vaccine.

By contrast, after receiving the Sabin vaccine, no children remained who lacked antibodies to all three types, and the range of response was 95%, 98% and 87% for the three poliovirus types, respectively.

Euler Made Easy

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The dual purpose of this paper is to develop an elementary justification of Euler's relation, $e^{i\theta}=\cos\theta+i\sin\theta$, and to show how it is used to develop the laws of operations with complex numbers.

The process of developing the theorems for multiplication, division, powers and roots of complex numbers is somewhat involved when using the trigonometric form—$r(\cos\theta+i\sin\theta)$. However, when one has at his disposal the exponential form, $re^{i\theta}$, the solution is relatively simple.

The problem would seem to resolve itself into the following questions:

1. What would be the ingredients of such a development of Euler's relation?
2. How does one obtain its justification?
3. How is it used to develop the theorems for multiplication, division, powers and roots of complex numbers?

Justification:

Assumptions (question one above)

a. The basic laws of exponents for real numbers also apply to complex numbers.
b. The usual rules of calculation and comparison for complex numbers.
c. $e^{i\theta}$ is a complex number with $e^{-i\theta}$ as its conjugate.

To justify:

$$e^{i\theta}=\cos\theta+i\sin\theta.$$

Justification (question two above)

Let us functionally write $e^{i\theta}$ in rectangular form:

(1) $$e^{i\theta}=f_1(\theta)+if_2(\theta),$$

a consequence of (c) above, then

(2) $$e^{-i\theta}=f_1(-\theta)+if_2(-\theta)$$

—by replacing θ with $(-\theta)$:

The conjugate of $f_1(\theta)+i f_2(\theta)$ is $f_1\theta - i f_2(\theta)$. Since $e^{-i\theta}$ is the conjugate of $e^{i\theta}$, then

(3) $$f_1(\theta)-if_2(\theta)=f_1(-\theta)+if_2(-\theta).$$

By the equality of two complex numbers,

$$(4) \qquad f_1(\theta)=f_1(-\theta) \quad \text{and} \quad f_2(-\theta)=-f_2(\theta)$$

and (3) becomes

$$(5) \qquad e^{-i\theta}=f_1(\theta)-if_2(\theta).$$

Now multiply (1) and (5), then

$$(6) \qquad 1=f_1^2(\theta)+f_2^2(\theta).$$

It is known that $\sin^2\theta+\cos^2\theta=1$ will satisfy (6). It remains to be determined which is $f_1(\theta)$ and which is $f_2(\theta)$. Equation (4) above answers this question. Since $\cos\theta=\cos(-\theta)$ and $\sin(-\theta)=-\sin\theta$, then $f_1(\theta)=\cos\theta$ and $f_2(\theta)=\sin\theta$, and $e^{i\theta}=\cos\theta+i\sin\theta$ which was to have been determined.

How (question 3 above) is $e^{i\theta}=\cos\theta+i\sin\theta$ used to develop the theorems for multiplication, division, powers and roots of complex numbers?

Multiplication:

To prove that

$$r_1(\cos\theta_1+i\sin\theta_1)r_2(\cos\theta_2+i\sin\theta_2)=r_1r_2[\cos(\theta_1+\theta_2)+i\sin(\theta_1+\theta_2)].$$

In other words to multiply one complex number by another (in trigonometric form) one must multiply the absolute values, r_1 and r_2, and add the angles.

Let

$$r_1(\cos\theta_1+i\sin\theta_1)=r_1e^{i\theta_1}$$

as determined above and

$$r_2(\cos\theta_2+i\sin\theta_2)=r_2e^{i\theta_2}.$$

Then

$$(r_1e^{i\theta_1})(r_2e^{i\theta_2})=r_1r_2e^{i(\theta_1+\theta_2)} \text{ which}=r_1r_2[\cos(\theta_1+\theta_2)i\sin(\theta_1+\theta_2)]$$

also from above.

It is left to the reader to use Euler's relation to develop the theorems for division, powers and roots of complex numbers.

The writer has spent quite some time attempting to develop such an elementary approach, having first developed several others on a higher academic level before reducing them to the above elementary form. This has been tried out in several classes and has been received very favorably by the students. It is believed that this justification will be of considerable use to teachers of both high school and elementary college mathematics.

New Patterns for Magnetic Field Mapping Laboratory Experiments

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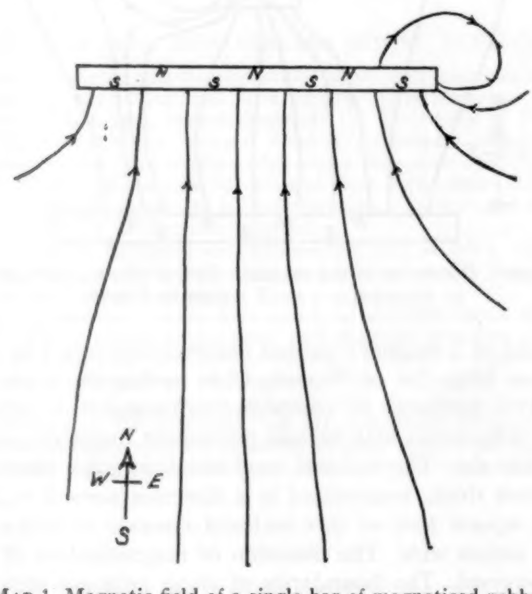
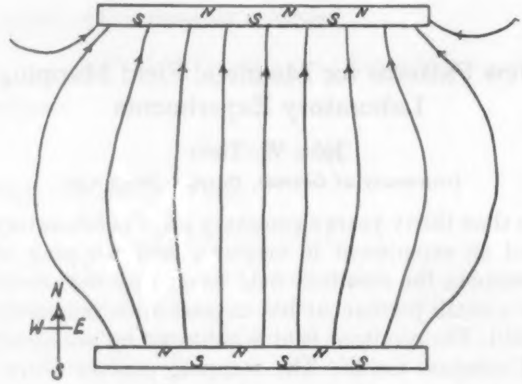
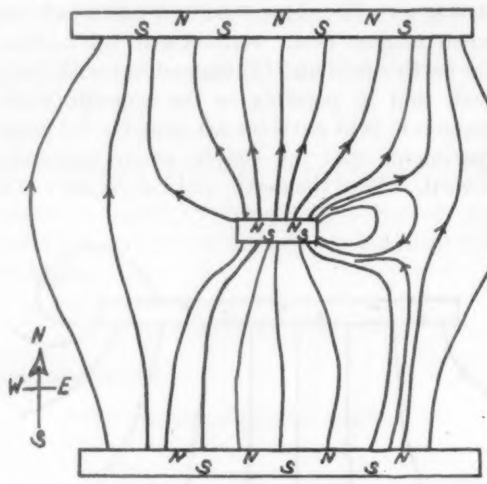
For more than thirty years elementary physics laboratory manuals have offered an experiment in magnetic field mapping which consisted of mapping the resultant field formed by the combination of the field of a small permanent bar magnet with the earth's parallel magnetic field. The resultant field is indicated by the direction taken by a small compass needle. The mapping process which is a well known procedure, traces the lines of the resultant field. The completed map exhibits two neutral points located some distance from the permanent bar magnet. The three standard patterns resulting when (1) the permanent magnet is set transverse to the earth's field, (2) aligned with the earth's field and (3) aligned but with the permanent magnet reversed, that is, pointing in the opposite sense, are well known. New magnetic field patterns are possible for supplementary laboratory experiments that are simple, easily manipulated, independent of the weak field of the earth, and informative. This is possi-



MAP 1. Magnetic field of a single bar of magnetized rubber.



MAP 2. Magnetic field of two bars of magnetized rubber.



MAP 3. Distortion of the magnetic field of two magnetized bars by interposing a small magnetized body.

ble by means of a magnetic rubber material developed by the Denman Rubber Mfg. Co. of Warren, Ohio having the trade name of Denmag. It is produced by compounding neoprene or other rubber and plastic substances with various permanent magnetic materials of small particle size. The material used comes in a flat sheet approximately $\frac{1}{4}$ inch thick, magnetized in a direction normal to the plane surface. A square foot of this material consists of strips approximately $2\frac{1}{2}$ inches wide. The direction of magnetization of adjacent strips is reversed. The boundaries of these adjacent strips can be

determined with a small magnetic compass. The strips may then be cut out with a band saw. These uniform strips can then be cut into smaller strips $\frac{1}{4}$ inch wide so that square rods of magnetic rubber are formed having one face exhibiting north polarity and the opposite face exhibiting south polarity. For this experiment, rods were cut to 5 inch and 1 inch lengths.

A study of the three plots will enable the reader to formulate laboratory directions. Attention should be called to the magnetic analogy of the finite charged sheet in electrostatics and to the simulation of the plate capacitor of limited size. The quality of lateral repulsion of lines of induction is apparent. Distortion of a uniform field by introducing a magnetic or charged body is shown.

Questions such as the following may close the experiment:

(1) Is there a neutral point in map 3?
(2) If a diamagnetic particle of matter were freely suspended just above plot 3, where would it tend to locate?
(3) If a paramagnetic particle were free to move in a line midway between the long rods of plot 2, where would it tend to come to rest?

SCIENTISTS FIND HOW VIRUSES INJURE HOST CELLS

Viruses grow inside the cells they infect and injure their host cells by producing excess amounts of viral "skin" and viral "insides" in two separate processes.

Dr. Harold S. Ginsberg, microbiologist at the University of Pennsylvania School of Medicine, told the National Academy of Sciences meeting that cells grown in tissue culture and infected with adenovirus show striking changes in their nuclei. The nuclei increase in size and show large dark-staining masses and crystals composed of millions of virus particles. The damaged cells also become round and clump in grape-like clusters.

The virus particles contained deoxyribonucleic acid, or DNA, which usually serves as the "core" in the mature virus, and protein, usually wrapped around the DNA like an overcoat, or skin.

The larger intranuclear masses were mostly viral DNA, which differed from normal cell DNA in chemical properties and chemical structure and was produced in surplus amounts. Viral protein was also produced in excess proportions.

The conclusions drawn from the studies are that the nucleic acid of adenoviruses is derived from a new and unique DNA; that the parts or subunits, DNA and proteins, of the infectious virus are synthesized independently; that these components of the virus are produced in great excess; and that the accumulation of these surplus virus precursors lead to injury of infected cells.

The Encouragement of the Amateur as a National Policy

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Amateurs have been defined as those primarily fun-oriented, as workers in an avocation, as men and women who receive little or no pay, and as people without formal training in their activity. Without regard for the description, amateurs have been responsible for much progress in science. Probably they must be credited for the wheel, fire, and agriculture.

In more modern times, comparable pioneers can be named. Leonardo DaVinci received training in sculpture but contributed to biology and engineering; Agricola (Georg Bauer) was a physician and teacher, not a mining engineer; Rene Descartes graduated in law, not in mathematics; Otto von Guericke was a diplomat, not a physicist; William Gilbert was a physician, not a physicist; D'Alembert (Jean LeRond) studied theology, law, and medicine but was self-taught in mathematics. Benjamin Franklin did not study electricity in school. Neither did Joseph Priestley and Sir Humphrey Davy have formal training in chemistry. Charles Lyell was a lawyer, and yet founded historical geology. Edward Lartet was a lawyer and began the search for the fossils of prehistoric man. Brashear, the lens designer, was a Pittsburgh coal miner. Paul Tannery, the French historian of science, was a clerk.

This list of amateur scientists who train in one field and do research in another includes many more than these. Indeed, many professional scientists would be so classified. Moreover it has been said that ninety percent of the scientists of all times are alive today. Thus momentous discoveries must be credited to the remaining ten percent and amateurs who are probably designated as amateurs.

Prior to the twentieth century, financial support for amateurs was sporadic. Few Priestleys had their Lord Shelburnes, and fewer Gilberts had their queens. Patrons were scarce and governments were not sympathetic. Strangely, the situation has not changed in modern times despite the growing importance of science and the increasing number of amateurs.

Any large urban area in the United States has organized activity for amateur astronomers, geologists, photographers, radio operators, and ornithologists. The "Amateur Scientist" columns in the *Scientific American* receives contributions from high-school students and from well-known professionals and tradesmen. Unfortunately, many amateur scientists do not join groups. Imprisoned Robert Stroud, the Bird Man of Alcatraz, has only a third-grade formal education and is an expert in avian pathology.

In view of the national need for scientists, it would seem worthwhile for national agencies to give financial encouragement to the amateur. This important sector has been neglected in our efforts to spur science. It may be a source of valuable contributions. The amateur has many possibilities to free himself from the prejudices of the learned and begin anew. He may be a source of vital and challenging thoughts. It would seem to be to our advantage to encourage their activities whether or not any of the current amateurs becomes a celebrated scientist.

NEW INSTRUMENT DETECTS COSTLY OIL-WELL LEAKS

An instrument has been developed to detect weaknesses in oil-well walls that could result in costly oil leaks. This weakness is caused by corrosion, a multimillion dollar problem in the oil industry each year.

Designed by Shell Development Company engineers, the instrument measures the effect of corrosion in a well casing by drawing an "electronic profile" of the thickness of the steel wall lining the well. Its gauge can detect where the wall was eaten away only one two-hundredth of an inch deep, which can be corrected in time before an oil leak develops.

Woodland Areas as Outdoor Laboratories*

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An outdoor laboratory is an area used by schools to vitalize their teaching in the area of science, conservation, and outdoor education. This area ideally should be near the school. It can then be used easily from time to time by the teacher and students as they reach areas in their curriculum where it is better to have an outdoor experience with the subject matter being studied. The more varied the natural features, the more educational use can be made of it and if it is controlled by the school, various kinds of educational work experiences can also be incorporated in the laboratory, as well as some recreational features to encourage its use at other times. It should be thought of as an outdoor classroom where various kinds of projects, interpretations and demonstrations can be in continuous progress. There can be varied activity and simple research at various grade levels. The changing of the seasons and the year to year changes of the plant and animal community can be a learning device for developing some of the more important concepts in conservation.

Many types of areas could be used to an advantage by a school. Even a small area of half an acre can be of value, and areas can range up to large land areas that might belong to the town or to the state. Cooperation with state and resource agencies can not only make available a varied terrain, but also give help in interpreting the environment. Parts of a school forest may be set aside for an outdoor laboratory. Part of the school grounds in many cases can be utilized for an outdoor laboratory. Actually any piece of land not in use, which the school can control, may be utilized to start an outdoor laboratory.

To get full use from the laboratory, the planning for it should be done by a committee representing all the levels of the school so that activities can be worked out appropriate to the various grade levels. This planning committee should also include some people who have experience with our natural resources to give technical advice.

An outdoor laboratory located close to the school can have on it a variety of projects. Children can be involved in the systematic management of forest trees by doing pruning, thinning, and weeding with advice from a forester, and carry on a long-term planting program for trees. In much the same way attention can be directed toward the wildlife management of the area, and the various shrubs and grasses that would encourage more wildlife can be ascertained and set out by children. Demonstration areas can be set up to show types of erosion. Small areas can be mapped and plotted and allowed to develop to

* Presented at the Association for the Advancement of Science, New York—December, 1960.

demonstrate effects of various uses. Soil profiles can be made and the various areas of the laboratory can be identified by soil type with the aid of the Soil Conservation Service. To adequately study an area, type maps of various kinds should be made. Maps can be prepared showing soils, tree locations, shrubs that furnish food for birds, wild flowers, etc., giving practice in the use of maps and compasses and the visual representation of an area.

Procedures for planning an outdoor laboratory and its activities are very important, as planning is often a major problem in conservation. Other uses for the laboratory such as constructing a nature trail, building wildlife shelters, bird feeding stations, weather stations, and if there is a stream through the area, the improvement of a small portion of the stream or the building of a small pond can all have meaning to students. These activities are much more meaningful if records are kept and the results of the investigations are recorded for use by later classes and for the continuation of certain projects. There is no better way for students to become acquainted with methods of science and to acquire conservation understandings than by the adoption of a land area for an outdoor laboratory.

In some of the above projects, it will be noted that work would be part of them. Work experience can be valuable, as few children today have the opportunity to do real work. Conservation work which contributes to the betterment of land use and the community can have esthetic meaning and significance to the children and teachers who do it, and they will be forever identified with it.

A good outdoor laboratory should have well constructed signs with explanations of the various projects being carried on. This not only makes the area more meaningful to children but serves as a good public relations instrument, so that the rest of the community understands what the children are doing and the educational significance of their activities.

These are only a few of the suggestions which could be worked out and planned for in an area. Of course many of them depend upon the particular area, and a study of an area would be necessary to decide which activities would be best suited to it and to a local school curriculum. As the school becomes more closely identified with the area, there will be many more ideas and ways of using it. If the area is large enough, part of the planning should include the recreational use of the area with such activities as the development of a picnic spot and cookout area. If there is a pond, it can be used for the development of some fishing.

A Variation on a Simple Technique for Stroboscopic Photography

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A useful and fascinating technique in the high school physics laboratory is that of stroboscopic photography. A variety of motion experiments can be performed using the strobe technique, lending a sense of realism to the study of motion which is difficult to match. Several suitable techniques have been described in various publications, including that employed in the laboratory procedures of the Physical Science Study Committee physics course, of which the following is an adaptation.

For the laboratory not fortunate enough to have as a part of its equipment a Polaroid type camera, a low-cost box camera arrangement can be effected. Here, then, is a method which has been tested by this writer and has produced satisfactory results at a very modest cost. Certain limitations are encountered compared to other methods, of course. These are not of a critical nature, however; they will be noted later.

Having experienced some lighting and background difficulties (probably due to limited experience in photography) in a first attempt at strobe photography, the writer found the clue to success in the recollection of a method employed by Mr. W. S. Burton (of the George School, Bucks County, Pennsylvania) at a PSSC summer institute for science teachers. It was desired to use the rotating, slotted disc in front of a box camera, as described in the PSSC laboratory guide. The object of the attempt was to photograph a falling ball in successive positions at equal time intervals during its fall, and from data extracted from such a photograph to compute a value for the gravitational acceleration constant. One might ask at first thought, "Why not use one of the commercially available photographs, and save all the fuss?" In the "fuss," however, lies the fundamental beauty of the experiment (as in many PSSC-type experiments): there is something to be gained from the actual *doing* in a laboratory or classroom which cannot be found in reading about or discussing the doings of someone else.

A simple, inexpensive, relatively foolproof photographic teachnique was desired, to be used in combination with the rotating disc. Having recalled, after some head-scratching, the use by Mr. Burton of a small lamp on a "frictionless" car, there followed this idea: if you can roll a lamp along a table, why not drop one? This was tried. A small, white, series-type Christmas tree bulb was wired and taped to a 45-volt radio B-battery, and an attempt was made to photograph

its fall to a foam rubber pillow from a height of about ten feet.

This sort of thing might seem a bit rough on lamps, but the lamp used in the first trials survived about ten such trips and was still available for its originally intended duty the following Christmas. The 45-volt battery was used with a lamp normally operated at 12 to 18 volts in order to increase the brightness available for photographic purposes.

A few words now about the camera and strobe device used. The camera was an ordinary box type, using 12-exposure number 620 roll film. Since these cameras normally have an aperture of about f 11, the short single exposure time provided by the slot in the rotating disc is not well suited for indoor photography. Hence the switch to a falling bright light from the original floodlighted falling ball. Kodak Tri-X film was used, but some experimentation might well produce other possibilities, especially with some of the now available super-fast films. Room lights were turned out and window shades drawn in order to produce as great a light contrast as possible. With the box camera, focus presents very little problem. It is necessary only to have the camera-to-subject distance sufficient to cover the field of the fall, being sure to keep about a ten foot minimum distance because of the fixed-focus lens.

The strobe disc used was essentially the same as that described in the PSSC laboratory guide, a motor-driven, slotted disc placed close in front of the camera lens so as to provide a brief, periodic exposure while the shutter was held open. A jig made of scrap wood was used to maintain the relative positions of the disc and the box camera. Various motors for driving the disc were used successfully, ranging from a small synchronous electric clock motor to an old induction type phonograph motor. In any case, since the rate of rotation of the motor may vary from its stated value with the load of the disc, *even in the case of the synchronous type*, the speed should be checked! This can be accomplished easily, within suitable tolerances, by the hand-operated disc method described in the PSSC laboratory guide, or by the conventional speed counter.

To achieve correct timing for the actual picture-making, a simple count-down procedure developed over several dry runs. With the motor already running, the lamp was dropped immediately after the camera shutter was opened; the shutter was closed when the lamp and battery struck the pillow. Accurate timing was important here because of the bouncing created by the foam pillow.

The number of images obtained is determined, of course, by the motor speed and the number of slots in the disc, for a given distance of fall. The greater the motor speed, the fewer slots are needed; in fact a single slot worked satisfactorily with all the motors tried. The

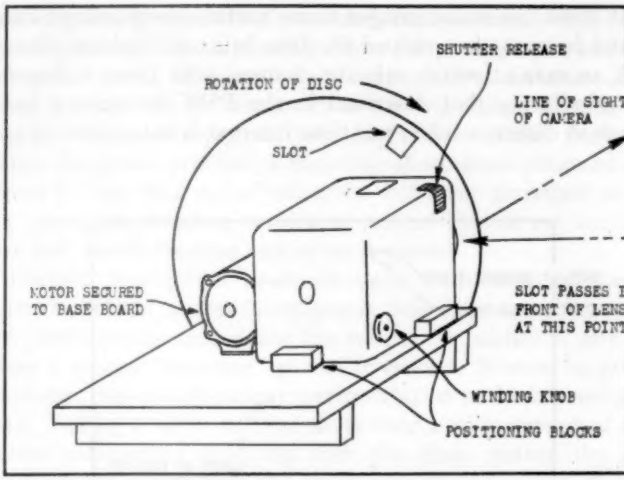

FIG. 1. Typical arrangement of camera and motor on base board. Not to scale.

arrangement finally used produced nine or ten images in the ten foot drop. A bit of private experimentation would seem to be the order of the day here. The *width* of the slot governs the length of each individual exposure; this, by the way, can be calculated easily from the speed of the motor, radius of the disc and size of the slot.

In order to make calculations, a distance reference in the photograph is needed. This was accomplished by placing in the picture area a meter stick with a lamp at each end. A scale factor was thus available. In using the photographs produced in this manner, a copy of one of two or three samples was given to each student. Postcard sized enlargements, made commercially at about five cents each, were used, but if dark room facilities are available one may obtain some further control over the results (as well as a saving in time and money). A word about students seems to be in order here. While this is matter of individual preference, this writer encourages them to work together in groups of two or three on a project of this sort. Sometimes they can learn more from each other than from the most conscientious instructor, *if* the ground work has been well laid by the instructor.

In calculating the gravitational constant, the time interval between exposures and the distance fallen during each successive time interval must be known. The time interval is, of course, the period of rotation of the disc if a single slot is used, or half the period if two slots diametrically opposed are used, etc. If the motor speed with a

single slot gives too many images to be useful, every second image can be used for measurment and the time interval doubled. The acceleration, or rate at which velocity changes with time, is found in a manner similar to that described in the PSSC laboratory guide. The change in distance fallen per time interval is calculated by sub-

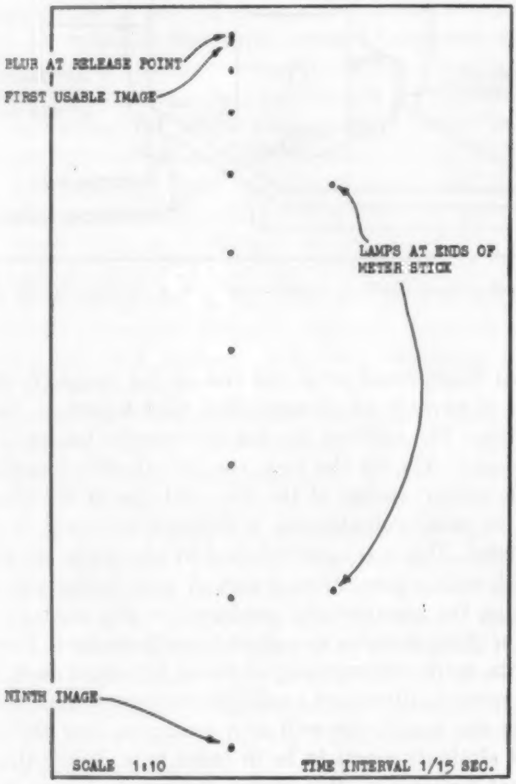

FIG. 2. Drawn from typical photograph made with single slot disc.

tracting the distance fallen in interval 1 from the distance fallen in interval 2, distance 2 from distance 3, etc., and averaging the values; this average is then divided by the time interval. The acceleration due to gravity is obtained by dividing again by the time interval, thus producing a distance/time/time fraction in whatever units were used for measurement.

Using dividers, or simply a ruler, measurements can be taken to two significant figures directly from the photograph, and converted using the meter stick scale factor into actual distances fallen. The time interval can be measured to two significant figures also. This gives a reasonable expectation of precision in the final calculated value. In actual practice, a majority of students obtained values between 9.5 and 10.2 m/sec^2 using the technique described and allowing for correction of gross measuring errors. This is not earth-shaking, but well worth the time and effort involved.

Certain limitations seem obvious. Compared to the Polaroid camera method, a disadvantageous time lag occurs between taking the photographs and seeing the results. In addition, any errors require a second "shooting" period to correct. It must be pointed out, however, that a little prior experimentation and rehearsal goes a long way. Taking a series of trial shots over a wide spread of conditions before attempting anything with the class, noting the conditions carefully for comparison with the results, should provide the necessary answers to questions concerning size of slot, speed of rotation, type of film for a particular camera, etc.

On the credit side, the cost in time and money is small: a 50-minute class period and something under five dollars (including an extra roll of film for prior experimentation) produced prints for about 50 students in the original trial. The use of the falling light seemed to eliminate most of the headaches of strobe photography with a box camera. In addition, having once obtained a good negative, prints are possibly more economical than Polaroid copies. By carefully noting the conditions under which a good negative was produced, it is relatively easy to duplicate the conditions another time.

Some other possibilities seem suitable for further trials in this type of a setup. If the lamp can be dropped, why not catapult it to study projectile motion (à la PSSC)? And why not a "falling bomb" type to study the independence of the horizontal and vertical motions? Why not?

References

1. Physical Science Study Committee, "Laboratory Guide" to *Physics*, D. C. Heath and Co., Boston, 1960, experiments I-1 and III-7 (or Preliminary Edition of same, prepared by the PSSC and published by Educational Services Inc., 1958–59, experiments 20, 30 and 130.)
2. Sutton, R. M., *Demonstration Experiments in Physics*, McGraw-Hill, New York, 1938, demonstrations M-86, p. 41, S-49, especially pp. 152–153.
3. White, Harvey E., *Physics, An Exact Science*, D. VanNostrand, Princeton, 1959, pp. 8, 9.

Problem Department

Conducted by Margaret F. Willerding

San Diego College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problem should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margeret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2776, 2779. *Jeff Payson, Prescott, Ariz.*

2779, 2781. *Brother Feliz John, Philadelphia, Pa.*

2785. *Proposed by G. P. Speck, Geneseo, N. Y.*

Without the use of tables, determine which is greater e^π or π^e

Solution by Merrill Barnebey, Grand Forks, N. D.

Whichever is greater, e^π or π^e, will have the greater natural logarithm.

$$\ln (e^\pi) = \pi \ln e = \pi$$
$$\ln (\pi^e) = e \ln \pi.$$

Due to the nature of the logarithm curve, $\ln \pi < \pi/e$,

$$\therefore \ \ln (e^\pi) > \ln (\pi^e)$$
$$\therefore \ e^\pi > \pi^e.$$

Solutions were also submitted by T. R. Curry, Oyster Bay, N. Y. and Rogers J. Newman, Baton Rouge, La.

2786. *Proposed by George S. Cunningham, Concord, N. H.*

What are the smallest non-negative distinct integers such that the difference of the cubes of two integers is precisely equal to the difference of the cubes of the other two integers?

Solution I by Brother Felix John, Philadelphia, Pa.

$$1^3 - 9^3 = 10^3 - 12^3.$$

Solution II by Merrill Barnebey, Grand Forks, N. D.

$$16^3-15^3=721, \qquad 9^3-2^3=721,$$

hence the integers in question are 2, 9 and 15 and 16.

2787. *Proposed by Enoch J. Haga, Turlock, Calif.*

A gentleman, who was about to begin a tour of Europe, worked out a secret code with his banker which he intended to use in case he should find himself short of funds. After some weeks, the banker received this wire from Europe: SEND. The gentleman, hearing nothing from his banker, sent another wire in a few days which read MORE. The banker, now remembering the code, sent this reply: MONEY. The gentleman was relieved when shortly after he got the needed funds. How much did he receive?

Solution by The Proposer

Obviously, SEND+MORE=MONEY. M=1, in order to provide a carryover to the next position. Assuming that S=9, and that the letter O probably equals the number 0, the rest of the digits are easy to find:

$$\begin{array}{r} \text{SEND} \\ +\text{MORE} \\ \hline \text{MONEY} \end{array} \qquad \begin{array}{r} 9567 \\ +1085 \\ \hline 10652 \end{array}$$

So \$10,562 was received by the gentleman.

2788. *No solution has been offered.*

2789. *Proposed by David Wiley, San Diego, Calif.*

Does

$$\sum_{n=1}^{\infty} \frac{1}{n^{1+1/n}}$$

converge?

Solution by Merrill Barneby, Grand Forks, N. D.

This series approaches more and more closely, it can be made as close as desired, to the known divergent harmonic series

$$\sum_{n=1}^{\infty} \frac{1}{n}.$$

Therefore the series is properly divergent.

A solution was also offered by Charles T. Salkind, Brooklyn, N. Y.

2790. *Proposed by C. W. Trigg, Los Angeles City College.*

A circle of radius r_1 is inscribed in an angle, the distance of its center from the vertex of the angle being d. A second circle, with a smaller radius r_2 is drawn tangent to the first circle and to the sides of the angle. (a) Find an expression r_2 in terms of r_1. (b) Test the result by summing the diameters.

Solution by C. N. Mills, Sioux Falls College, S. D.

Let O be the vertex of the angle, C_1 the center of the given circle, and C_2 the center of the required circle, T the point of tangency of the given circle, and θ the angle between OT and OC_1. $OT^2=d^2-r_1^2$. Then

$$\cos\theta=\frac{\sqrt{d^2-r_1^2}}{d}.$$

Also $OC_2=d-r-r_1$. Then

$$\sin\theta = \frac{r}{d-r-r_1}.$$

Since $\sin^2\theta+\cos^2\theta=1$, gives

$$\frac{r^2}{(d-r-r_1)^2}+\frac{d^2-r^2}{d^2}=1.$$

Simplifying, we get

$$r=\frac{r_1(d-r_1)}{d+r_1}.$$

Part (b) is not clearly stated.

Solutions were also offered by Merrill Barnebey, Grand Forks, N. D.; Jack Fellman, Dorchester, Mass.; and Warren Rufus Smith, Brooklyn, N. Y.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

PROBLEMS FOR SOLUTION

2809. *Proposed by Merrill Barnebey, Grand Forks, N. D.*

Diophantus did not have a watch but his *n*th descendant did. This same descendant had a rather routine job working moderately long each day. Early on the job one day he glanced at his watch and said to himself; "Well, my day is exactly one fifteenth done and my morning is 15% done."

How long was his day? How long was his morning? What time was it?

2810. *Proposed by Floyd D. Wilder, Bethany, Okla.*

Given two curves $F(x)$ and $G(x)$ which intersect at the point (x_0, y_0), both curves are non-decreasing over the interval $a \leq x \leq b$, where $a=x_0$ and b is any, arbitrary value. Find the equation of the curve with will bisect any line with slope m drawn through the two curves over the given interval.

2811. *Proposed by Cecil B. Read, Wichita, Kan.*

Show, without the use of tables, that an approximate value of $\pi/16$ is arc tan $1/5$.

2812. *Proposed by Fred A. Miller, Elkine, W. Va.*

A 20 foot ladder rests against a vertical wall. A cat starts to climb the ladder at 1 ft. per sec. and the foot of the ladder moves along the floor at 1 ft. per sec. Find: a) the equation of the curve described by the cat; b) maximum distance from the floor; c) maximum distance from the wall; d) maximum distance from the corner; e) distance traveled by the cat; f) the velocity of the cat at the end of 16 sec.

2813. *Proposed by Brother Felix John, Philadelphia, Pa.*

The sides of an inscribed hexagon, taken in order, are 15, 15, 7, 15, 15, and 7. Find the radius of the circumcircle.

2814. *Taken from "Fascinating Figure Puzzles."*

In how many ways may a family of ten persons seat themselves differently at dinner?

EDITOR'S NOTE: THIS DEPARTMENT IS IN NEED OF SOME NEW AND INTERESTING PROBLEMS.

Books and Teaching Aids Received

BIOLOGY

BIOLOGY, ITS PRINCIPLES AND IMPLICATIONS, by Garrett Hardin, Cloth, 25×18 cm., 1961, 682 pages, W. H. Freeman and Company, 660 Market Street, San Francisco 4, California. Price: $8.00.

CHEMISTRY

CHEMISTRY IN ACTION, by George M. Rawlins, Alden H. Struble, and Claude W. Gatewood, Cloth, 24×16 cm., 1961, 583 pages, D. C. Heath and Company, Boston, Massachusetts. Price: $5.56.

MATHEMATICS, COLLEGE

CALCULUS, by Tom M. Apostol, Cloth, 25×18 cm., 1961, 515 pages, Blaisdell Publishing Company, 22 East 51 Street, New York 22, New York.

MATHEMATICS, MISCELLANEOUS

THE TEACHING OF ARITHMETIC, by F. F. Potter, Cloth, 18 by 12 cm., 1961, 462 pages, Philosophical Library, Inc., 15 East 40th Street, New York 16, New York. Price: $4.75.

SCIENCE, ELEMENTARY

ICEBERGS AND GLACIERS, by Patricia Lauber, Cloth , 23×16 cm., 1961, 64 pages, The Garrard Press, 510 North Hickory, Champaign, Illinois. Price: $2.25.

ELEPHANTS, by William D. Sheldon, Cloth, 23×16 cm., 1961, 66 pages, The Garrard Press, 510 North Hickory, Champaign, Illinois. Price: $2.25.

SCIENCE, MISCELLANEOUS

THE UNIVERSE AND DR. EINSTEIN, by Lincoln Barnett, Paper, 18×10 cm., 1960, 128 pages, The New American Library of World Literature, Inc., 501 Madison Avenue, New York 22, New York (A Mentor Book). Price: $ .50.

BASIC SCIENCE HANDBOOK K-3, by Wilbur L. Beauchamp and Helen J. Challand, Cloth, 24×20 cm., 1961, 352 pages, Scott, Foresman and Company, Chicago, Illinois. Price: $3.20.

THE WONDER OF HEAT ENERGY, by Hy Ruchlis, Cloth, 24×15 cm., 1961, 186 pages, Harper & Brothers, 49 East 33rd Street, New York 16, New York. Price: $3.95.

MISCELLANEOUS

TEACHING BY MACHINE, by Lawrence M. Stolurow, Paper, 23×15 cm., 1961, 173 pages, U. S. Department of Health, Education, and Welfare, U. S. Government Printing Office, Washington 25, D. C.

THE USE OF ACADEMIC PREDICTION SCALES FOR COUNSELING AND SELECTING COLLEGE ENTRANTS, by Benjamin S. Bloom and Frank R. Peters, Cloth, 23×15 cm., 1961, 145 pages, The Free Press of Glencoe, Inc., 60 Fifth Avenue, New York 11, New York. Price: $5.00.

PROBABILITY AND EXPERIMENTAL ERRORS IN SCIENCE, by Lyman H. Parratt, Cloth, 23×15 cm., 1961, 255 pages, John Wiley & Sons, Inc., 440 Park Avenue South, New York 16, New York. Price: $7.25 Trade Ed., $6.00 College Ed.

ELEMENTARY TEACHERS GUIDE TO FREE CURRICULUM MATERIALS, Edited by Patricia H. Suttles, Paper, 27 cm.×21 cm., 346 pages, Educators Progress Service, Randolph, Wisconsin, 1961, 18th Edition. Price: $7.50.

LIST OF PUBLICATIONS, American Geological Institute, Paper, 21×10 cm., 6 pages, American Geological Institute, 2101 Constitution Avenue, N. W., Washington 25, D. C.

THE SCIENCE LIBRARY SERIES. All paper. All 12.5×20.5 cm. 1961. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y.

CAUSALITY AND CHANCE IN MODERN PHYSICS, by David Bohm, foreward by Louis DeBroglie. 170 pages. Price $1.35.

A MODERN INTRODUCTION TO LOGIC, by L. Susan Stebbing. 525 pages. Price $2.75.

TURNING POINTS IN PHYSICS, essays by R. J. Blin-Stoyle, D. terHaar, K. Mendelssohn, G. Temple, F. Waismann, D. H. Wilkinson, 192 pages. Price $1.45.

THE NATURE OF THERMODYNAMICS, by P. W. Bridgman. 236 pages. Price $1.50.

ROCKET DEVELOPMENT, by Robert H. Goddard. Paper. 12.5×20.5 cm. 222 pages. 1961. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. Price $2.45.

THE ANNUAL CONFERENCE ON HIGHER EDUCATION IN MICHIGAN, November 17 and 18, 1960. Paper. 15×23 cm. 59 pages. The University of Michigan, Office of Publication, Ann Arbor, Michigan.

ELECTRON MICROSCOPE REVEALS NEW HEREDITY MECHANISM

A new discovery on the mechanics of heredity has resulted from direct examination by electron microscopy of the giant molecules involved.

The highly magnified look at the DNA (deoxyribonucleic acid) molecule, which controls the transmission of inherited characteristics has revealed that a different process may be involved in the self-duplication activity by which living organisms perpetuate their kind. Two classes of DNA molecules, each composed of long chains of nucleotides, arranged respectively in double spirals and pairs of double spirals, have been found.

In studies of pneumococcus DNA, it was found that the two double spirals of the molecule lie side by side rather than intertwined with each other, as previously believed.

It was believed that replication in heredity involved the uncoiling of these strands, but now it appears rather that each double spiral transfers its genetic information by forming an entirely new adjacent double spiral.

This makes it easier to understand the mechanics of replication at the higher chromosomal level.

Book Reviews

McGRAW-HILL ENCYCLOPEDIA OF SCIENCE AND TECHNOLOGY. Cloth, 17×25.5 cm. 15 Volumes, 1960. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 36, N. Y.

The characteristics that are evaluated in reviewing a book, article, or research report are quite different from those used with an encyclopedia. One reads, or should read, page by page the former publications, whereas it would be most difficult to scrutinize every page of a series of volumes as extensive as an encyclopedia. The task would be all but impossible with an encyclopedia of science and technology since it would require specialized knowledge beyond that of any single reviewer or even a group of reviewers of practicable size. Any encyclopedic publication such as this one in order to be evaluated sensibly must be put to use and evaluated on certain specific criteria, among them the following:

1. Does the encyclopedia provide the specialized information sought by the user?
2. Is information located quickly and easily?
3. Are the entries complete and written in readable style?
4. Does it meet the points mentioned in 1, 2, and 3 above better than other publications designed for the same purpose?

In the case of this encyclopedia, the answer to each of these questions is an unqualified "Yes." The reviewer believes that the *McGraw-Hill Encyclopedia of Science and Technology* is far superior to any other encyclopedia or compendium now published in so far as the science, technology and engineering are concerned.

The *Encyclopedia of Science and Technology* consists of 15 volumes, covering about 9300 pages in which there are slightly more than 7200 entries. As with the last volume of almost all encyclopedias, Volume 15 is the *Index*. The entries, or articles vary from 100 to as many as 15,000 words. While it would be all but impossible to validate the many entries, the eminence of the Editorial Advisory Board and the consulting editors are the best assurance one could have of the integrity of the various entries. The many and varied illustrations add not only to the attractiveness of the volumes but also to their clarity.

The volumes were used during the review period by (1) graduate students in science, (2) participants in In-Service Institutes sponsored by the National Science Foundation, (3) students from sixth grade through the high-school, and (4) by a number of college instructors for purposes too numerous and varied to be discussed here. In every case, the search elicited the desired information quickly and easily. The reviewer for example sought and quickly found information about diverse topics such as these:

1. The diameter of two of the famous meteorite craters.
2. The period of development of the lamprey.
3. The composition of printing ink.
4. A comparison of the relative speeds and tractive efforts of diesel and electric locomotives.
5. The specific rotation of sucrose.

The reviewer was especially impressed with the utility and cross-referencing of the Index. For those who want more information than the entries provide, the bibliographies provided with major topics are extremely valuable.

It is not difficult for a reviewer to describe a publication with cursory platitudes that are all but meaningless. However, in his best and honest judgment, it seems that this document should be on the shelves of every high school, college and university where students search for scientific information. There is ample empirical evidence that it is useful also for junior-high-school students and some of the better students at the sixth-grade level.

GEORGE G. MALLINSON

Basic Concepts in Modern Mathematics, by John E. Hafstrom, *Department of Mathematics and Engineering, University of Minnesota, Duluth.* Cloth. Pages x+195. 23×15 cm. Addison-Wesley Publishing Company, Inc., Reading, Mass. 1961. Price $5.75.

The question of what should be included in a one quarter or semester mathematics course which is required for students outside the fields of science, engineering, or mathematics will probably be with us for some time. The author has selected certain topics for such a terminal course, recognizing that other selections might be made. The topics selected, in the words of the author, "lend themselves to the construction of number systems." He feels it better to delve somewhat deeply into a few concepts rather than to treat many topics superficially. Some faculty (perhaps particularly those outside the field of mathematics) will fail to understand his statement " . . . I believe it advisable to include topics having a ready application." In other words, it is not inconceivable that certain individuals will fail to see any "ready application" for most of the material in this text.

Whether this is a suitable text will depend upon the nature of the course—in fact the reviewer feels that the selection of this book as a text would almost determine the nature of the course. The nature of material covered is perhaps best indicated by lising chapter headings: The Natural Numbers; Sets, Variables, and Statement Forms; Mappings and Operations; Groups; Relations and Partitions; The Integers; The Rational Numbers; The Real Numbers. The author points out that the last two chapters are unsuitable for the terminal course described, but might serve as a bridge between the traditional freshman-sophomore sequence and a course in modern abstract algebra (the reviewer feels the material of these two chapters hardly adequate for an intermediate course).

Certainly the treatment is more thorough than is found in many "survey" texts. Not all teachers will agree with the author that a background of one year of algebra and one of geometry is adequate.

In general the reviewer was pleased with the treatment. As examples where the treatment of material seems above average, one might mention the illustration of the equivalence of two ways of writing a terminating decimal as a repeating decimal (infinitely many 0's or infinitely many 9's). Again, the proof of the irrationality of $\sqrt{2}$ is a little out of the ordinary. On the other hand, there are a few spots where there might be a feeling of inadequate discussion. The student, without the help of a good teacher, might, for example, find difficulty with the treatment and definition of the product of two sets (page 50).

Certainly any instructor interested in a course with content somewhat as outlined by the chapter headings cannot afford to neglect examining this book as a possible text.

Cecil B. Read
University of Wichita

A WORLD OF NUMBERS . . . AND BEYOND

The visitor touches a button, and 30,000 plastic balls cascade down a 12-foot-high "pinball" machine to settle each time into an identical "curve of probability. . . . "

The visitor keys a number, and that number is multiplied and squared in the glowing lights of a giant 512-bulb cube. . . .

The visitor pulls a plunger and launches a miniature sphere, which orbits around a center as a planet does around the sun. . . .

These are ways that noted designer Charles Eames has brought "Mathematics" down from the scientific stratosphere onto the plane of popular understanding to show how probability laws, multiplication tables, and laws of motion and gravitation actually work.

The "prove it yourself" audience-participation models are in a new permanent exhibit, "A World of Numbers . . . and Beyond," at the California Museum of Science and Industry in Los Angeles.

The exhibit, sponsored by the International Business Machines Corporation, was the first to be installed in the Museum's new $2,375,000 Science Wing, and is designed throughout to explain in simple, visual terms the fundamental concepts of mathematics.

It is expected to be viewed by more than 1,000,000 visitors annually. The Museum is open to the public without charge from 10 A. M. to 5 P. M. daily.

"We hope," said Eames, "that this exhibit will do much to broaden the image of mathematics in the mind of the uninitiated. There is excitement, adventure, and suspense. In fact, mathematics is perhaps the world's greatest 'Who-Done-It.' Fortunately, many of the clues can be enjoyed without being a detective."

Besides the giant working models, the designer used animated films, "peep show" devices, and a variety of imaginative visual explanations to make the exhibit an informal schoolroom for science-education as well as an interesting show.

Special tours for school classes are arranged by the Museum's education director.

In seeking a dramatic presentation of a complicated subject in plain-language terms, Charles Eames and his wife, Ray, and staff spent more than a year in research, read 2,500 books on the subject, ranged from England to Japan for source material. Eames was assisted by Raymond Redheffer, professor of mathematics at the University of California at Los Angeles.

Much of the massive research for the exhibit was done at Columbia University in New York, whose Plimpton and Smith collections of mathematics volumes are considered the best in the United States. Other university libraries consulted included Brown University, Cal Tech, Princeton, the University of California (both UCLA and Berkeley campuses) and Yale. Also utilized were the New York Public Library, the Metropolitan Museum of Art, and the library maintained by Metro-Goldwyn-Mayer.

"Early in our planning," said Eames, "we were surprised to hear this statement: 'If mathematics is a mile, what you learned in high school is the first inch.'

"This meant that pre-college math was but one part in 60,000. This statement began to make more sense as we caught glimpses of the remaining 59,999 parts. Some of the parts were richer knowledge about old familiar numbers. But most, by far, were new concepts, new relationships and fine abstract bridges.

"So the exhibit became: 'A World of Numbers . . . and Beyond.' In it we try to give some clues to the richness, variety, beauty and excitement that make up that mile."

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